II - PLANT COMMUNITY ANALYSIS

ANALYSIS OF THE GROUND FLORA AND OTHER DATA COLLECTED DURING THE 1991 PRINCE EDWARD ISLAND FOREST INVENTORY

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by

DOUGLAS G. SOBEY

of

School of Applied Biological & Chemical Sciences
University of Ulster
Jordanstown, Northern Ireland
United Kingdom
&
A Research Associate of
The Institute of Island Studies
University of Prince Edward Island
Charlottetown, P. E. I., Canada

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ABSTRACT

In 1991 a large scale Forest Biomass Inventory of Prince Edward Island was carried out by the provincial Forestry Branch at 1200 sampling points located at 240 randomly-selected forest sites. At each sampling point, data was collected on the ground flora species present in 4 m^2 plots, and also on the nearby trees and shrubs, as well as on general properties of the surrounding forest stand. A soil pit was dug near the sampling point and soil samples were taken for the analysis of soil micro- and macronutrients. Additional topographic, historical and soil data for each sampling point was later obtained from maps and the 1935 aerial photographic survey. As a result, a large amount of data was available for each of the 1200 sampling points.

The ground flora data for 1127 of the 1200 plots were subjected to classificatory and ordination procedures using two multivariate computer programs – TWINSPAN and DECORANA. On the basis of their ground flora composition, TWINSPAN divided the plots into eleven different groups ranging in size from 12 to 196 plots. These ground flora groups were then subjected to further descriptive and comparative analysis in terms of their tree canopies, forest stand properties and all of the recorded environmental factors.

Analysis of the TWINSPAN classification of the ground flora indicated that an important factor associated with the different ground flora groups were differences in their tree canopies – a principal distinction occurred between hardwood-dominated and conifer-dominated sites : four of the eleven groups were hardwood-dominated – these were subdivided into a 'wet hardwood' ground flora plot type – on soils with poorer drainage (subdivided into a wetter and dryer type), and three 'dry hardwood' plot types, representing three different ground flora community variants associated with tolerant hardwood forest on dry upland soils. The five main conifer-dominated ground flora plot types appeared to belong to three major forest types : (1) cut-over or disturbed forest on dry soils – dominated by balsam fir with smaller contributions from red and white spruce, (2) old-field white spruce woods, and (3) black spruce - dominated bog and heath forest. Detailed descriptions and discussion of all of these ground flora groups and vegetation-types are presented.

The DECORANA ordination indicated the general relationships between the TWINSPAN groups, and suggested that in overall terms the most important factors responsible for the ground flora and forest-types produced by the classification are soil moisture levels and the effects due to past human disturbance.

The information emerging from this unprecedented objective, quantitative and widescale survey of the Island's forest vegetation is compared with the few relevant previous studies, and various applications of the analyses are discussed.

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Very special thanks are due to William Glen of the Prince Edward Island Forestry Branch whose foresight lead to the assembling of a vast data-set relevant to the 1991 Inventory containing so much useful and unprecedented data – not only on the forest trees but on the ground flora and soils – Bill continually provided unstinting help and advice throughout the study. I also thank Brian Hearn of Forestry Canada for providing support and advice during the 1992 study leave; Harry Baglole of the Institute of Island Studies at the University of Prince Edward Island for arranging the research associateship which enabled me to use library facilities at the University; Ian MacQuarrie of the University of P.E.I. – who provided useful advice at the beginning of the study; Dan McAskill of the P.E.I. Forestry Branch for helpful advice; and Brian Rushton of the University of Ulster and Delmar Holmstrom of Agriculture Canada, Charlottetown for reading and commenting on a draft version of parts of this report.

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TABLE OF CONTENTS

ABSTRACT i

ACKNOWLEDGEMENTS ii

INTRODUCTION 1

METHODS 2

RESULTS 7

DISCUSSION 23

ADDENDUM : Some Further Discussion Points 25

RECOMMENDATIONS 33

REFERENCES 34

APPENDIX 1. The forest vegetation-types of Prince Edward Island : Summary descriptions for each of the eleven principal Ground Flora Groups generated by the TWINSPAN analysis. 37

APPENDIX 2. The forest vegetation-types of Prince Edward Island : Analysis and discussion of the eleven principal Ground Flora Groups generated by the TWINSPAN analysis. 69

APPENDIX 3. Tables presenting detailed analytical and statistical comparisons of the vegetation and environmental properties of the eleven principal Ground Flora Groups generated by the TWINSPAN analysis. 97

APPENDIX 4. DECORANA ordination of the ground flora plots assessed in the 1991 Prince Edward Island Forest Inventory. 129

APPENDIX 5. A comparison of the properties of the two sub-groups of Ground Flora Group 3, generated at the fifth TWINSPAN division level. 145

APPENDIX 6. Inter-correlations between the quantitative soil and topographical variables 157

APPENDIX 7. Scientific and common names of plant species mentioned in this report. 161

APPENDIX 8. The use of the indicator species in classifying 'unknown' plots using the TWINSPAN classification. 167

INTRODUCTION

In 1991 the Prince Edward Island provincial Forestry Branch carried out the field work for its second ten-yearly comprehensive Inventory of the province's forests. Although the primary purpose of the Inventory was to obtain data on the timber biomass and quality of the commercial tree species, for the first time information was also collected on the ground plants occurring at each of the 1200 sampling points assessed in the Inventory. The Forestry Branch hoped that in the long term such information might aid the development of guidelines for the silvicultural management of forest sites so as to conserve the rarer ground flora species.

I became involved in the analysis of this ground flora data during a six-month study leave from the University of Ulster in 1992. My first report (Sobey 1993) presented a *floristic* analysis of the data collected, i.e. what woodland ground flora and tree species were recorded by the Inventory, where they were recorded in the province, and how their frequency and distributions compared with the results of the only two previous assessments of the Island's woodland ground flora: that in Erskine's *Plants of Prince Edward Island* (1960, 1985), and the results of a survey of candidate woodland natural areas conducted by the Island Nature Trust in the 1980's.

This second report goes on to adopt a *plant community* approach to the analysis of the data. In particular, using multivariate analytical methods (i.e. ordination and classification) the 1200 sampling plots will be classified (i.e. subdivided into smaller groups of similar species composition) and ordinated (i.e. arranged along gradients of changing plant community composition) on the basis of the species composition of their ground flora. The plant community groups and gradients emerging can then be characterized in terms of the environmental data collected during the Inventory and subsequently – e.g. topographical factors, soil factors, the associated tree dominants, forest age, forest condition, and management and historical factors. Such an approach will enable for the first time in the botanical history of the province, the recognition and characterization of distinct forest ground flora plant communities and plant community gradients, as well as their distribution on the Island, their tree associates and possibly the effects of management practices on them.

Classification and ordination are two long-established procedures for the analysis and simplification of complex multivariate data on plant communities (e.g. Gauch 1982). In essence, these two different approaches are derived from two opposing views of the nature of variation in plant communities – ordination being based on the view that plant communities are continuously variable in composition; classification, that they comprise distinct and recognizable types. In reality, both concepts are likely to have a validity even for the same vegetation data set, and there is thus an advantage in using both techniques together.

The results of multivariate analysis of the 1991 Inventory data will not only be of interest in theoretical and conservation terms but may ultimately be of value in practical forest production : ground vegetation is being increasingly used in Canadian forestry as an indicator of the potential tree productivity of forest sites, and elaborate site classification systems based on the ground vegetation have been developed in other Canadian provinces (e.g. Jones *et al.* 1983; Corns & Annas 1986; Meades & Moores 1989; Sims *et al.* 1989; Zelazny *et al.* 1989). Although the 1991 ground flora data was not specifically collected for this purpose, the Forestry Branch was aware of its potential in developing such a system for the province in the future.

The Forestry Branch initially proposed to carry out a more extensive ground flora survey than was ultimately achieved: four separate 1 m^2 plots were to be assessed at each of the 1200 sampling points, and additional ground flora species in the general area outside of the sample plots were to be listed. However, because of insufficient financial resources this had to be reduced to the assessment of the species in a single 4 m^2 plot without any listing of surrounding species. The implications of this for the multivariate analyses will be discussed later.

My principal aim then is to use multivariate analytical techniques to extract the maximum amount of information on the forest plant communities of Prince Edward Island from the great quantity of data collected at 1200 sampling points in the 1991 Forest Inventory or derived from published maps, and to evaluate this information in terms of what it reveals about the forest communities at present and possibly in the past. It was my hope that the analysis would lead to a precise documentation of the variation in Island forests and a greater understanding of the environmental factors determining the variation. I will also in a preliminary way consider some of the uses to which the data might be put.

METHODS

FIELD METHODS

The Prince Edward Island Forest Biomass Inventory was carried out by two teams of workers (four persons) between June and September 1991 at 240 forest sites (Figure 1). These were selected randomly prior to the field visits using numbered kilometre squares marked on Department of Energy and Forestry Road Atlas maps (scale 1:50,000, i.e. 2 cm = 1 km) in which forested areas are shown in green (the Road Atlas maps were in fact Canada Department of Energy, Mines and Resources (1976) maps reprinted in a booklet form). For each kilometre square randomly chosen the sample site was placed in that forested area nearest to the centre of the square, ignoring areas too small to contain the cruise line. If a kilometre square did not contain or overlap any woodland of sufficient size, it was rejected. During the actual field sampling at the site, five sampling points were located, at usually 100 m intervals, along a cruise line whose compass-bearing and starting point (to avoid any bias) had been determined prior to the field visit and marked on aerial photos (scale 1:17,500) to aid location. To enhance inclusion of different forest types along the cruise lines, the lines were chosen beforehand to run across map contour lines – where such occurred. The first sampling point was usually 100 m in from the wood edge. Alder scrub and clear-cut areas were to be excluded in the actual sampling and no sampling point was to be closer than 15 m to a boundary between two distinct forest types. With five sampling points at each of the 240 randomly chosen sites, there was a total of 1200 sampling points in the Inventory.

GENERAL SITE FACTORS – At each of the 1200 sampling points the assessors recorded the slope (in degrees) and the aspect (in eight directional classes), and the following standard forest inventory data for the site based on a subjective impression of the general area around the sampling point (see Haddon (1989) for a definition of the terms) : (1) the forest type (i.e. whether predominantly hardwood (HH - > 75% hardwood, HS - 50-75% hardwood) or softwood (SS - > 75% softwood, SH - 50-75% softwood)); (2) the broad age class of the trees (regeneration, immature, mature, overmature, uneven-aged); (3) the stocking class of the trees (as four quartile percentage classes); (4) where evident, the management history and origin of the stand (i.e. swampy, bog, burn, partial cut, thinning, clearcut, plantation, old field, or a combination of these); and (5) evidence of damage due to logging, insect defoliation, disease and windfall.

SOIL FACTORS – A soil pit was dug near the sampling point and using standard soil survey techniques the following physical properties were determined in the field : soil drainage class (well, moderately well, imperfectly, poorly drained); rooting depth (cm); thickness of the A horizon (cm) (i.e. the distance from the beginning of the mineral soil under the H horizon to the B horizon) ; root restriction factors (a high water table or soil compaction); and the texture of the B horizon. Soil samples were taken from the H horizon (just above the mineral soil) and the B horizon (so as to include the upper and lower part of the B) for subsequent analysis of pH, total carbon and nitrogen, and available levels of the following macro- and micronutrients : phosphorus, potassium, calcium, magnesium, sulphur, boron, manganese, iron, copper and zinc.

The chemical analyses were carried out by the Prince Edward Island Department of Agriculture, Fisheries and Forestry Soil and Feed Testing Laboratory in Charlottetown using the following methods : the soil samples were oven-dried overnight at 40°C, ground in a soil crusher and passed through a 2 mm sieve. The pH was detemined electrometrically on a 1:1 volume ratio of the ground and sieved soil and distilled water; total carbon and nitrogen were determined by combustion on a CHN analyser; available Ca, Mg, K, P, S, B, Mn, Fe, Cu, and Zn were extracted using a Mehlich III extract at a 1:10 soil to extract ratio, shaken and filtered, and run on an Inductively Coupled Argon Plasma (ICAP) Spectrometer. For carbon and nitrogen, final values were expressed as percentages in oven-dried soil, for all of the other elements, as parts per million.

VEGETATION ASSESSMENT – At each sampling point the total vegetation was assessed in four separate categories:

1. **Trees** – defined as ≥ 9 cm dbh (diameter at breast height – i.e. 1.3 m) including standing dead trees. These were assessed using a standard forestry technique called 'point sampling' or 'plotless cruising' (e.g. Haddon 1989; Watts 1983). This involved the use of a 'variable radius plot' centred on the sampling point, with trees being selected for inclusion in the sample using a wedge prism of Basal Area Factor = 2 m^2. The species and dbh (to the nearest cm) of each tree was recorded, as well as

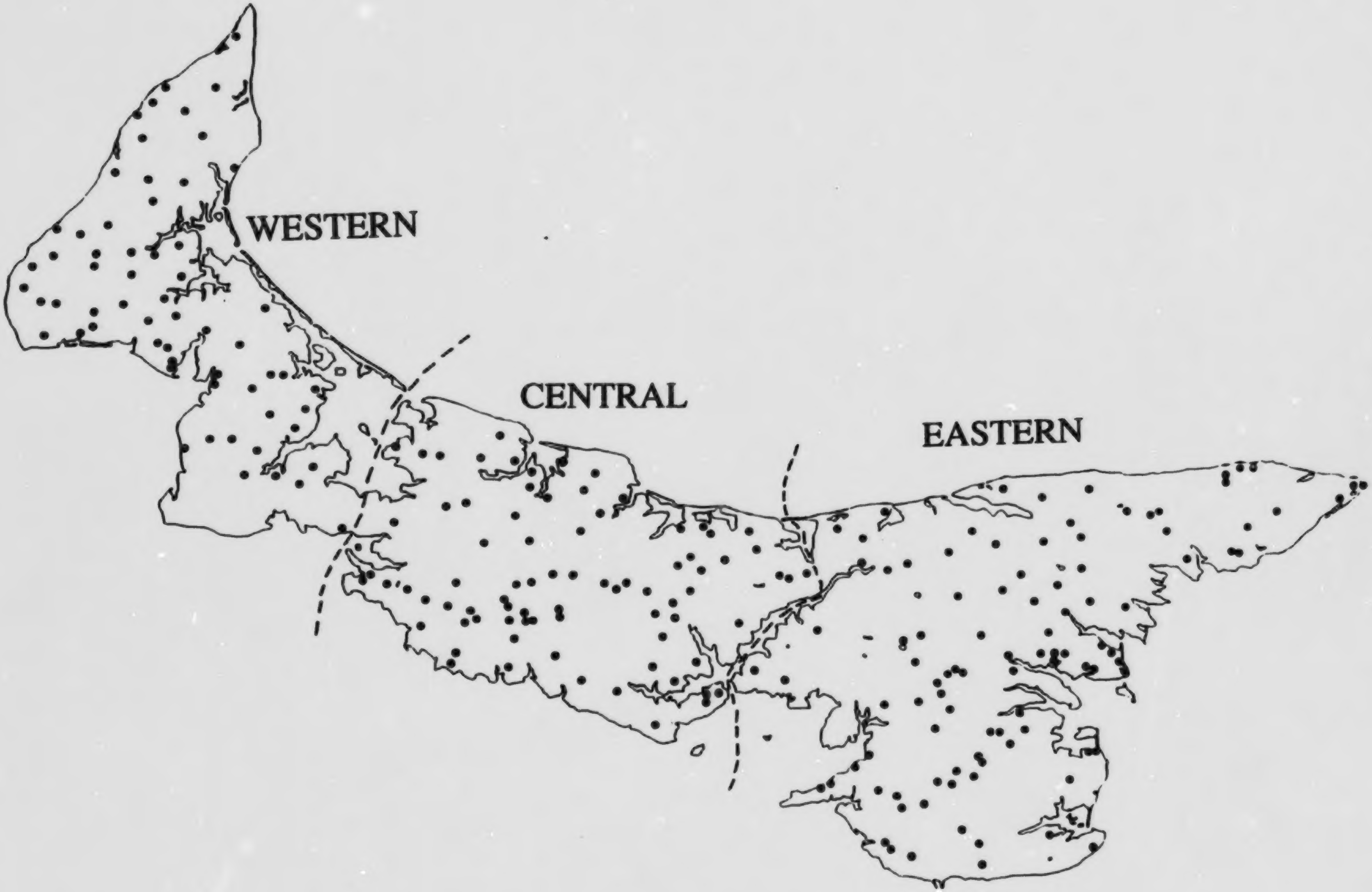
WESTERN
CENTRAL
EASTERN

FIGURE 1. The location of the 240 sampling sites assessed in the 1991 Prince Edward Island Forest Inventory. The three regions into which the island was divided for the purpose of this study are also shown.

information on its wood product quality and defects. Two trees, generally the largest broadleaf and conifer, were selected for measurement of dbh, height (using a clinometer) and age at breast height (1.3 m) (using an increment borer).

The tree data collected were used to calculate many further parameters relevant to the overall Inventory but only two are of direct relevance to the ground flora study : the percentage contribution (to the nearest 10%) of each tree species to the total woody biomass in the variable radius plot – based on calculations derived from the tree tally and the measurements of their basal area; and the 'actual density' of the trees in the variable radius plot – a measure of stocking on the stand (recorded as a percentage) calculated from the tree diameters and numbers recorded, compared with general stocking rates for the species or species group.

2. **Small trees and woody shrubs** – defined as ≥ 1.3 m in height but less than 9 cm dbh. These were assessed within a 16 m^2 circular plot (radius 2.26 m) centred on the sampling point. Each individual plant was identified as to species and vitality (living or dead), and its dbh was recorded to the nearest cm.

3. **Regeneration trees** – defined as any of 37 commercial species of trees and shrubs of a height of at least 15 cm but less than 1.3 m. The number of such trees for each species was tallied within a circular 4 m^2 plot (radius 1.13 m), the centre of which, to avoid the effects of the trampling involved in the tree sampling, was moved 5 m onward from the sampling point along the bearing of the cruise line.

4. **Ground flora** – all species of vascular ground plants including ferns, clubmosses and horsetails; forbs, grasses and sedges; and woody shrubs < 1.3 m in height but excluding the commercial tree species assessed as regeneration trees; and selected species of mosses, liverworts and lichens were assessed within the same 4 m^2 circular plot used for the regeneration tree assessment. Based on a visual impression of its cover-abundance, each species or other taxonomic category was given a percentage cover value to the nearest 10% with a minimum value of 5%.

For most plants, identification was carried out to the species level but for some difficult taxa only the genus was identified (i.e. *Amelanchier, Salix*), while for others, either the species or the genus was identified, depending on the stage of development of the particular plant and the experience of the assessor (i.e. *Aster, Carex, Equisetum, Habenaria, Hieracium, Solidago, Cladina, Viola*). Frequently grasses were grouped under 'Grass' and most moss species under 'Moss' – other than those to be identified specifically. The principal botanist involved in the survey was Mr. Douglas Kelly who had considerable previous experience in identifying ground plants in the province's forests. (See Sobey (1993) for a complete listing of all of the species recorded in the Inventory, and Appendix 7 for a list of the species mentioned in this report.)

All field data was fed directly at the site into a portable data collector (Digitech Memo MD-3) and later transferred to a PC computer database file (D-Base IV) set up for the purpose.

MAP DERIVED DATA

In addition to the data collected in the field, further information on each of the 1200 sampling points was obtained from maps or aerial photographs. The following data of this type was provided by the Forestry Branch:

1. **Status of the plots in 1935** – The forest boundaries evident in the first aerial photographic survey of the province were transferred by photo-interpreters to maps which were subsequently digitized on computer and incorporated into the Geographic Information System (G.I.S.) database for the province. The database was queried for the status of each of the 1200 sampling points in 1935, with their status being recorded as one of the following : forest cover, cleared land, old field, road.

2. **The soil series type** – as defined by the Prince Edward Island Soil Survey (MacDougall *et al.* 1988). This was obtained for each plot from the P.E.I. Department of Agriculture, Fisheries and Forestry computerized map database for all sampling points, which had been derived from the 1:10,000

soil maps produced by the Soil Survey. Doubtful computer allocations were checked directly on the 1:10,000 soil maps. Where a map unit was listed as comprising more than one soil type, only the predominant type was recorded.

In addition, using ruler and compass I transferred the cruise lines drawn on the aerial photographs used by the field teams in locating the plots in the 1991 Inventory, to the 1: 50,000 P.E.I. Road Atlas maps, at the same time recording the distances between the plots (normally 100 m). (The Road Atlas maps, as noted above, were Canada Department of Energy, Mines and Resources maps reprinted in a booklet form – the information on the maps was current as of 1976.) I then recorded the following parameters for each of the 1200 sampling points:

3. **Geographical region** – the location of each sampling point was recorded as being in one of three geographical regions into which the island was divided (Figure 1) : (1) Western region : i.e. west of a line crossing the Bedeque-Malpeque isthmus; (b) Central region : between the Bedeque-Malpeque isthmus and the Hillsborough River; (3) Eastern region : east of the Hillsborough River and Tracadie Bay.

4. **Distance from the coast** – defined as the minimum straight-line distance (km) from the sampling point to the nearest sea coast (including that of bays such Malpeque, Cascumpec, New London and Rustico, but ignoring tidal rivers and estuaries). This was measured from either the 1: 50,000 Road Atlas maps (for those sampling sites near the coast where the coast was visible on the map sheet), or (for sites more distant from the coast) from a 1: 250,000 Canada Department of Energy, Mines and Resources map (1974) of the whole province.

5. **Distance from nearest road or building** – defined as the minimum straight-line distance (m) from the sampling point to the nearest building or road (whichever was nearer) as indicated on the 1: 50,000 Road Atlas maps (not counting as roads – 'trails, cut-lines or portages').

6. **Elevation** – the elevation above sea level of the sampling point was estimated from the contour lines (25 foot intervals) on the 1: 50,000 Road Atlas maps, with the values being converted to metres.

7. **Size of wooded area** – defined as the ground area (km^2) of the woodlot or forest in which the sampling point was located. This was determined from the 1: 50,000 Road Atlas maps – on which wooded areas are indicated by green shading. Green areas separated only by lines indicating roads were considered to belong to the same wooded area, while wooded areas connected only by a narrow corridor or isthmus of green were considered as separate woods. (Inevitably for some wooded areas an element of subjectivity was involved in delimiting their map boundaries.) From examination of the Road Atlas maps each sampling point was initially placed in one of three area categories : (a) ≤ 5 km^2; (b) > 5 km^2 but ≤ 10 km^2; (c) >10 km^2. For sites in the smallest category a more precise estimate of the area was then obtained by placing at random a transparent overlay of gridded dots on the map over the wooded area and counting the number of dots lying on the green map area (half-dots were counted as halves). The area of the wood was then calculated from an estimate of the number of dots per km^2 (38.6 ± 0.27 (S.E.) – which was determined from ten trials in which the overlay was placed randomly over a kilometre square of the map grid.

An additional parameter was obtained from another map :

8. **Corn heat units** – (an indicator of summer heat based on cumulative daily temperatures in the growing season – see Bootsma (1972)). The corn heat unit contour lines given in Figure 2, page 3 of MacDougall *et al.* (1988) were transferred by hand to a small computer-printed map (scale : 1 cm = 7.1 km) showing the exact location of the 240 sampling sites. Each of the sampling sites was then assigned a corn heat unit value as follows : points within $\leq$ 1mm of the contour line were given the unit value of that line, while the remaining points between two contour lines were assigned a value mid-way between the two contour line values. This resulted in nine corn heat unit categories ranging (at 25 unit intervals) from 2225 to 2425 units.

METHODS OF DATA ANALYSIS

All of the above field and map data was stored and analysed on the database management system dBASE IV using an IBM microcomputer. Prior to the analyses the plant species data were checked for any recording errors (e.g. duplicate entries, mis-coded species). The only error not correctable at this stage concerned two *Ranunculus* species – it is very likely (D. Kelly – pers. comm.) that all 23 of the records listed as RANRE (the code for *Ranunculus recurvatus*) were actually *R. repens* (code – RANRP); accordingly the records for these two species were combined as *Ranunculus repens.*

Two multivariate methods were used in this study : Two-way Indicator Species Analysis (TWINSPAN or TSA), a classificatory technique, and Detrended Correspondence Analysis (DECORANA or DCA), an ordination technique. Both have been specifically developed for the analysis of plant community data (Hill 1979 a, b; Gauch 1982) and have been used extensively in forest and other vegetation studies including several Canadian forestry studies (e.g. Jones *et al.* 1983; Corns & Annas 1986; Sims *et al.* 1989; Zelazny *et al.* 1989).

A specific advantage in applying TWINSPAN and DECORANA together is that they are both based on the same mathematical technique (reciprocal averaging) and are designed to be used in a complementary fashion on the same set of data, thus enabling both the recognition of plot groups comprising distinct plant community types and at the same time the spatial ordering of these groups and their individual component plots in terms of their overall similarity to each other.

In essence, TWINSPAN subdivides a group of plots on the basis of the presence of species identified in the analysis as 'differential' or 'indicator' species – i.e. those species showing the most distinct relationships (both positive and negative) with all of the other species in the species-plot data matrix. Starting with a large heterogeneous group of plots TWINSPAN subdivides this dichotomously into successively smaller groups ending up with plot groups of similar species composition. Simultaneously TWINSPAN also carries out a separate classification of the plant species, with species having similar distributions among the plots being grouped together.

In the DECORANA analysis, the plots (based on their overall species composition) are assigned numerical positions along axes, such that those plots which show the highest degree of dissimilarity are positioned at the extreme ends of an axis while plots with similar species composition are positioned closer together – many axes are generated in the analysis but usually only the first four are printed by the program. This information can then be summarized as one or more graphs in which all of the sample plots are plotted in a two-dimensional space based on their scores along two of the axes. Any pair of axes may be plotted together, though it is usually the first two that give an ecologically interpretable pattern. In such graphs, sample plots which are similar in overall species composition occur near each other, while dissimilar plots are farther apart. The graphs generated by DECORANA are useful for showing relationships between individual plots – or between groups of plots, particularly where the groups have been generated by the TWINSPAN analysis. Simultaneously DECORANA also scores the position of the plant species along these axes, with species having similar distributions among the plots occurring close to each other on the axes – the species can then also be plotted in two-dimensional diagrams.

TWINSPAN and DECORANA multivariate analyses were applied to the ground flora data at the University of Ulster using Cornell University computer programs (Hill 1979 a,b) which had to be modified to enable the analysis of all 1200 plots in a single run. Seventy-one of the 1200 plots were omitted beforehand from the analysis – 18 in which no ground flora species had been recorded and 53 for which no trees were recorded in the area of the sampling point. Of the 225 taxa recorded in the Inventory, 13 of the 16 non-specific genera were omitted from the analyses (the generic categories retained were *Amelanchier*, *Sphagnum*, and *Mnium*). All plant species occurring in fewer than five plots were also omitted – which resulted in two further plots being reduced to zero species, and these were also omitted from the analysis. In the end, 1127 plots, containing 128 taxonomic categories, were subjected to TWINSPAN and DECORANA.

The DECORANA ordination and TWINSPAN classification are based entirely on the ground flora data. The second stage of the analysis consists of the interpretation of the products of these analyses (i.e. the groups and two-dimensional graphs). The TWINSPAN groups need first to be characterized in terms of summary descriptions of their ground flora composition, and then to be interpreted in terms of any independently determined environmental data (including data on the tree canopy). Differences between the various TWINSPAN groups can be compared statistically, and the scores for the plots on the DECORANA axes can be tested for their correlation and/or association with the same independent environmental factors. In this second stage of the analysis dBASE IV was used to sort the plant and environmental data for the various TWINSPAN groups, and the computer package SPSS (Statistical Package for Social Scientists) (Norusis 1990) was used in the statistical analyses. Among the tests applied were : one-way analysis of variance (plus the Scheffe multiple comparison test), the χ^2 test of association, and Pearson's correlation coefficient. Because, in one-way analysis of variance a significant variance ratio statistic (F) only indicates that there are differences among the means but does not specify where the differences occur, the Scheffe multiple comparison test was used to determine which of the individual means were significantly different at a probability level of < 0.05. However, this procedure is conservative – i.e. it requires larger differences between means to achieve a given level of significance than most other methods – thus there are likely to be significant differences between more groups than are indicated by the Scheffe test – as is evident from a casual comparison of the means and standard errors of the various attributes for the TWINSPAN groups.

After the multivariate analyses had been completed, in order to verify in the field the validity of the TWINSPAN groups, and to record photographically the appearance of their ground flora, in the summer of 1994 (using the same cruise line compass bearing and distances as in the 1991 Inventory) I attempted to approximately relocate the sampling points of 26 plots selected as representative of the eleven TWINSPAN groups. A copy of the photographs have been deposited in the Prince Edward Island Collection at the Robertson Library of the University of P.E.I., and also in the provincial Forestry Branch library at Upton Road.

RESULTS

TWINSPAN : CLASSIFICATION OF PLOTS

The results for the TWINSPAN classification of the sample plots to the fourth division level are shown in Figure 2. At this level, fifteen TWINSPAN groups were generated. However, four of these (Groups 1, 2, 4 and 15) each contained fewer than ten plots and were not considered further. The eleven remaining TWINSPAN groups ranged in size from 12 to 196 plots – see Tables 3-1 and 3-2 of Appendix 3 for the frequencies of the ground flora species in each of the eleven groups.

Each of these groups was analysed and compared in terms not only of their ground flora species but also the composition of their tree canopies and the environmental factors operating on them. These analyses are presented in the Appendices : Appendix 1 contains a summary description of the floristic composition and the predominant forest stand and environmental factors for each of the eleven groups, plus maps of the Island showing the sampling sites at which they occurred; Appendix 2 presents an extensive analysis and discussion of the properties of each group; and Appendix 3 presents tables containing the detailed data from which these summaries and discussions have been derived, including analyses testing the statistical significance of differences between the groups.

During the above analyses it became evident that Group 3 was particularly heterogeneous, and so the two sub-groups of this group at the fifth TWINSPAN division level (Groups 3A and 3B) were later compared in detail – the detailed descriptions and discussion relating to these two sub-groups were added to Appendices 1 and 2, while Appendix 5 contains the detailed data tables comparing the two.

The following is a summary of the overall classification as presented in Figure 2 : in the first TWINSPAN division the 1127 plots were split into two almost equally-sized groups – one of these (the 595 plots to the left) largely comprising (as examination of the data for the tree canopy indicated – see Appendix 3 : Tables 3-3, 3-5) the ground flora plots of broadleaved woodlands, while the right-hand group, containing 532 plots, comprised the ground flora of conifer-dominated woodlands. The 595 broadleaved plots were then split into two groups, unequal in size – the smaller consists of 156 plots (Group 3) comprising the flora of the more nutrient-rich and wetter broad-leaved woodlands – at the fifth divison level (Figure 2) this was further divided into two sub-groups (Groups 3A and 3B, with 71 and 85 plots respectively) which differ in their soil drainage properties; the larger group of broad-leaved woodland plots (430 plots), contains the flora of the drier broad-leaved woodlands – this group was further divided into three sub-groups (Groups 5, 6 and 7) which appear to differ in relation to the amount of human disturbance that has occurred.

The 532 ground flora plots of conifer-dominated woodlands were divided into two groups of unequal size – the larger (439 plots) containing the ground flora of what subsequent analysis indicated to be the dryer and less acid conifer woods, the smaller (93 plots), the ground flora of the more acid and wetter black spruce - dominated forests. The larger group was subsequently split into two groups, each of which was subdivided in turn, resulting in four groups – two of which (Groups 8 and 9) are quite similar to each other and appear to represent cut-over or disturbed conifer-dominated forest on dry soils – (these plots are dominated by balsam fir with smaller contributions from red and white spruce), the third group (Group 10) consists largely of the flora of old field white spruce woods, and the fourth group (Group 11) is a species-poor group comprising only 21 plots, which analysis and field observation revealed to be more closely related to the broad-leaved plots than to the conifer plots. The 93 plots of the black spruce - dominated forest ended up as three groups, one of which (Group 12, with only twelve plots) contains an odd mixture of acid and more nutrient-demanding species – analysis and field observation suggests it represents a plot-type transitional between Groups 3 and 13. The other two groups represent the black spruce forest proper sub-divided into a poorly-drained bog forest type (Group 13) and a drier lichen-heath forest type (Group14).

Thus, although the TWINSPAN classification has led to the recognition of eleven plot groups at the fourth divison level – when these eleven groups are compared in terms of their species composition and environmental factors, supplemented by field observation, it is evident that, although each group has a certain ecological validity, some are really variants of broader community-types. When these variants are combined, the eleven ground flora groups can be reduced to five general forest-types : wet species-rich deciduous woodland (Group 3) ; dry hardwood forest (Groups 5, 6 and 7); disturbed conifer-dominated forest (Groups 8 and 9); old field white spruce woods (Group 10); and black spruce - dominated forest (Groups 13 and 14) sub-divided into a heath and bog type.

TWINSPAN : CLASSIFICATION OF SPECIES

Figure 3 and Table 1 show the species classification to the fifth division level including species of low frequency omitted from Table 3-1 of Appendix 3. At the first division level the 128 species were split into two groups, with the negative group (85 species) consisting largely of the species prevalent in the Ground Flora TWINSPAN Groups 3, 5, 6, and 7 (i.e. the broadleaved woodland groups), while the 43 species in the positive group are generally more prevalent in the conifer-dominated TWINSPAN groups. By the third division level these two large groups of species have been sub-divided into seven groups, two of which are quite large (i.e. Species Group II with 47 species and Species Group III with 26). The species groups generated at this level are not absolutely clear-cut but a comparison with the TWINSPAN classification of the plots (Appendix 3 : Table 3-1), and especially of the 'selective species' (Table 1), enables the following generalizations to be made about the ecological relationships of the species-groups : Species Groups I and II consist largely of the ground flora species prevalent in TWINSPAN Group 3 (i.e. the more nutrient-rich and wetter broadleaved woodlands); Species Groups III and IV, the species of TWINSPAN Groups 5, 6 and 7 (i.e. the dryer hardwood forest); Species Groups V and VI – of TWINSPAN Groups 8, 9 and 10 (i.e. the conifer-dominated disturbed and/or successional forest); and Species Group VII – the ground flora of TWINSPAN Groups 13 and 14 (i.e. the black spruce - dominated forest).

DECORANA : ORDINATION OF PLOTS

One value of the DECORANA ordination of the plots and species is that it demonstrates something that may be overlooked in a classification-only approach – i.e. that the data are essentially *continuous* and thus the boundaries produced by a TWINSPAN classification are not as clear-cut as that analysis might imply. It also helps to show relationships between the various TWINSPAN groups (plots with plots, species with species, and one with the other).

Figure 4 shows the position of the eleven TWINSPAN groups along the first two axes of the DECORANA ordination – the positions of the individual plots along the axes are shown for each group in Appendix 4. In Figure 5 a simpler picture is produced by combining the eleven TWINSPAN groups into the five major forest-types discussed above.

Figure 4 generally supports and clarifies the interrelationships between the TWINSPAN plot groups evident from the classification : Group 3 is largely distinctive from the other groups (though its two sub-groups broadly overlap in their positions – see Appendix 4 : Figures 4-13 and 4-14); the three hardwood groups (5, 6 and 7) overlap in position – 6

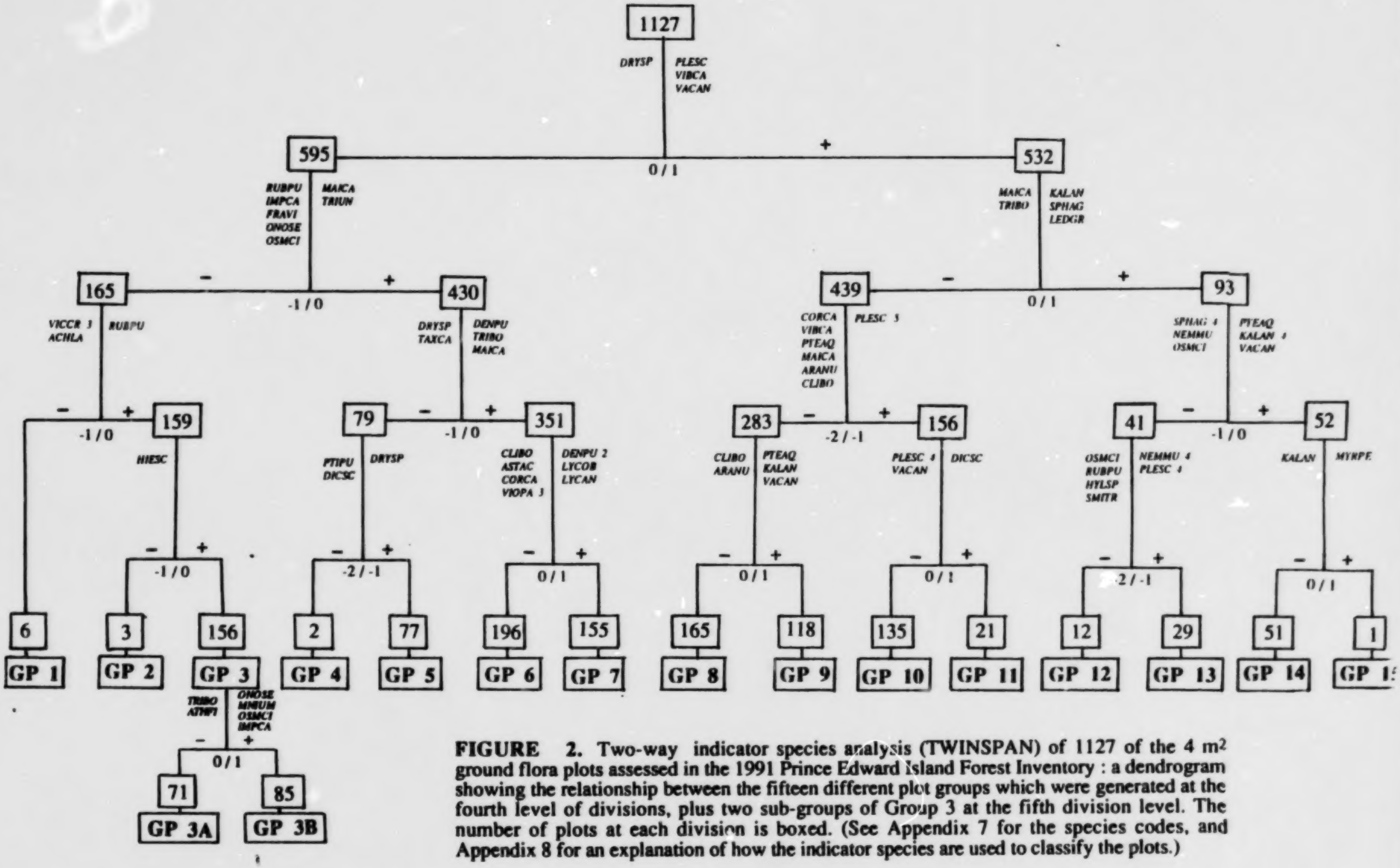
1127
DRYSP
PLESC
VIBCA
VACAN
0 / 1
+
595
RUBPU
IMPCA
FRAVI
ONOSE
OSMCI
MAICA
TRIUN
532
MAICA
TRIBO
KALAN
SPHAG
LEDGR
165
-1 / 0
430
VICCR 3
ACHLA
RUBPU
DRYSP
TAXCA
DENPU
TRIBO
MAICA
439
0 / 1
93
CORCA
VIBCA
PTEAQ
MAICA
ARANU
CLIBO
PLESC 3
SPHAG 4
NEMMU
OSMCI
PTEAQ
KALAN 4
VACAN
159
HIESC
79
PTIPU
DICSC
DRYSP
351
CLIBO
ASTAC
CORCA
VIOPA 3
DENPU 2
LYCOB
LYCAN
283
CLIBO
ARANU
PTEAQ
KALAN
VACAN
-2 / -1
156
PLESC 4
VACAN
DICSC
41
OSMCI
RUBPU
HYLSP
SMITR
NEMMU 4
PLESC 4
52
KALAN
MYRPE
6
3
156
2
77
196
155
165
118
135
21
12
29
51
1
GP 1
GP 2
GP 3
GP 4
GP 5
GP 6
GP 7
GP 8
GP 9
GP 10
GP 11
GP 12
GP 13
GP 14
GP 1
TRIBO
ATHFI
ONOSE
MNIUM
OSMCI
IMPCA
71
85
GP 3A
GP 3B

FIGURE 2. Two-way indicator species analysis (TWINSPAN) of 1127 of the 4 m^2 ground flora plots assessed in the 1991 Prince Edward Island Forest Inventory : a dendrogram showing the relationship between the fifteen different plot groups which were generated at the fourth level of divisions, plus two sub-groups of Group 3 at the fifth division level. The number of plots at each division is boxed. (See Appendix 7 for the species codes, and Appendix 8 for an explanation of how the indicator species are used to classify the plots.)

and 7 moreso than 5; the two conifer groups do overlap but Group 8 is pulled more towards Groups 6 and 7, while Group 9 overlaps more with Group 14; Group 12 (whose species make-up overlapped both Groups 3 and 13 – see Appendix 3: Table 3-1) does indeed lie between Groups 3 and 13; Groups 13 and 14 (the two black spruce - dominated groups) lie near each other; Group 10 (the white spruce group) overlaps a large number of groups – 8, 9, 11, 13, and 14. Figure 5 indicates that when groups similar in species composition are combined into five general vegetation-types, four of the groups occupy reasonably distinctive areas of the ordination while the fifth (Group 10 – the white spruce woods) shows more overlap with the other groups.

DECORANA : ORDINATION OF SPECIES

Figure 6 shows the species ordination – because it is mathematically related to the plot ordination, the positions of the species on the axes are directly comparable to the positions of the plots and thus also to the TWINSPAN groups (as in Figure 4) – though because the axes scores for each plot are the mean scores of the species that occur in it (Hill 1979b), the plot scores have a narrower range than the species scores, and the species thus tend to be more widely spaced in the ordination.

The species ordination indicates that the four ecologically significant combinations of species groups recognized in the TWINSPAN classification (Species Groups I + II, III + IV, V + VI, and VII) occupy reasonably distinctive regions of the ordination space of axes 1 and 2, and by comparing Figure 6 with Figure 4 it is evident that these regions correspond to those of the plot groups for which the species are selective. Plotting the sub-divisions of these larger species groups (i.e. all of the groups in Figure 3 or Table 1) would have resulted in a less clear-cut picture : there is much more overlap in the distribution of the species belonging to such sub-groups, making it impossible to draw boundary lines.

DECORANA ORDINATION : ENVIRONMENTAL FACTORS

Although each of the TWINSPAN ground flora groups has been described and analysed *individually* in terms of the independently-determined environmental factors operating on them (see Appendices 1, 2 and 3), the particular value of an ordination approach is that we are able to assess the relationship of such environmental factors to the *overall* distribution of all of the plots in the ordination space. This enables us to determine whether there are any *over-riding* environmental factors which are correlated with, and thus possibly responsible for, the ordination of all of the plots, and – because the ordination has been based entirely on the ground flora – for the ground flora make-up of the plots. For those factors for which we have *quantitative* measurement data, the appropriate procedure is to test the correlation for all of the plots between their position along a particular DECORANA axis (i.e. their numerical scores or co-ordinates on the axis) and their magnitudes for a particular factor.

Table 2 lists the Pearson coefficients for the correlation between the quantitatively-measured environmental variables (primarily topographical and soil chemical factors), and the plot scores along the first four axes of the DECORANA ordination. It is evident that no single environmental factor is dominant in the analysis (i.e. responsible for the major part of the pattern in the DECORANA analysis) : although for each of the axes quite a number of the variables were significantly correlated, none of the correlations was very high : for the soil factors the highest coefficient was only –0.24 and most are well below this value.

The correlations for the topographical factors are slightly higher than for the soil factors – the largest coefficient was 0.31 (for corn heat units on axis 3) – but as was apparent for the soil factors, no particular factor shows an exclusive relationship with a particular axis. Thus despite the fact that many of the soil and topographical factors did prove to be significant for particular TWINSPAN groups (see Appendix 3 : Tables 3-14, 3-15, 3-21), the DECORANA analysis suggests that we cannot invoke any of these factors as a single dominant explanation for the variation in the ground flora make-up of all of the plots. [1]

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[1] The soil and topographical variables are themselves inter-correlated with each other, some of them at high levels of significance – see Appendix 6.

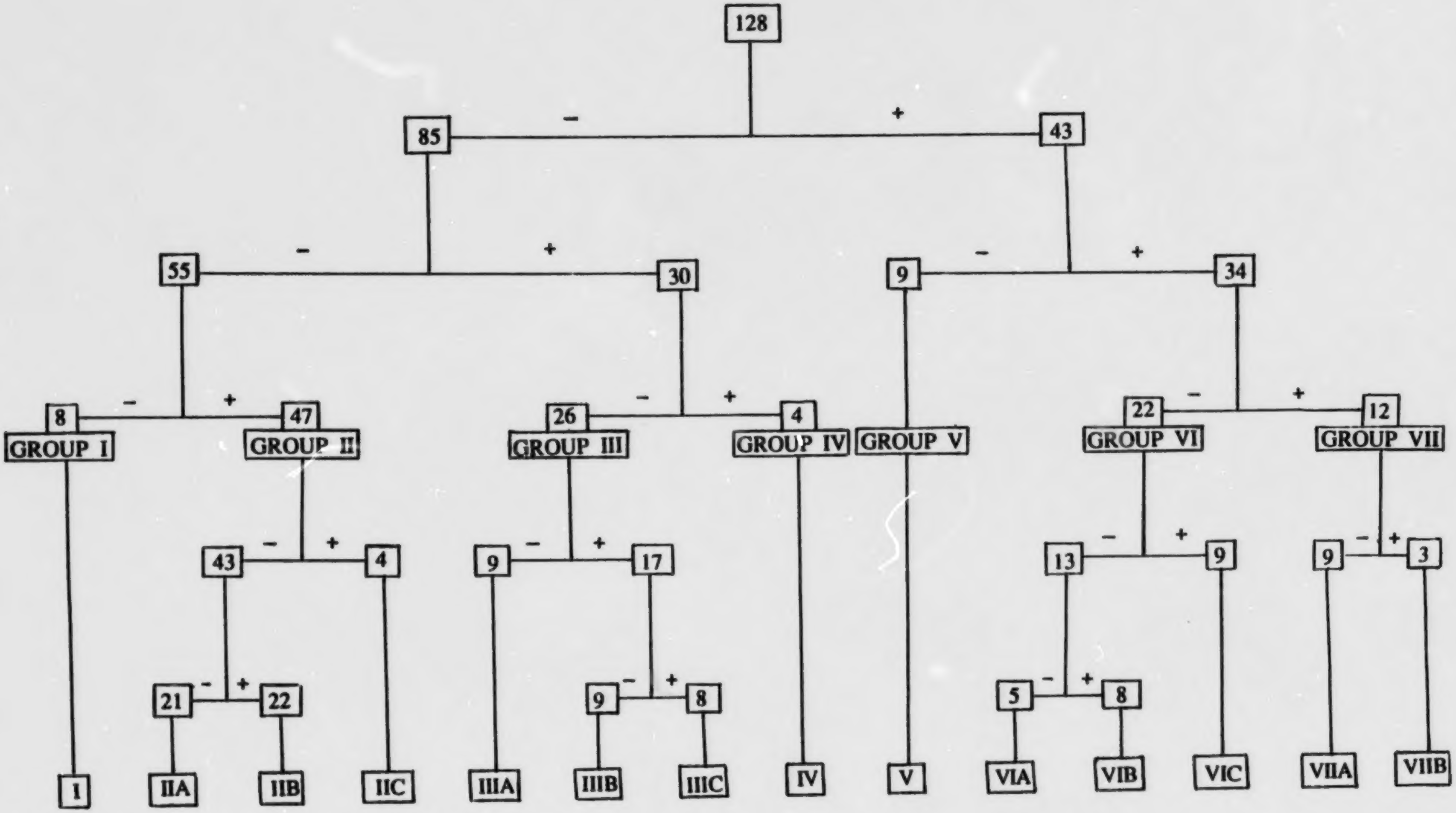
128
85
43
55
30
9
34
8
47
26
4
22
12
GROUP I
GROUP II
GROUP III
GROUP IV
GROUP V
GROUP VI
GROUP VII
43
4
9
17
13
9
9
3
21
22
9
8
5
8
I
IIA
IIB
IIC
IIIA
IIIB
IIIC
IV
V
VIA
VIB
VIC
VIIA
VIIB
–
+

FIGURE 3. The TWINSPAN classification of the 128 ground flora species included in the multivariate analysis of the ground flora data collected in the 1991 Prince Edward Island Forest Inventory : the dendrogram shows the relationship between the seven species groups generated at the third division level, and further sub-divides these into fourteen groups at the fifth division level. The number of species at each division is boxed. The species in each group are listed in Table 1.

TABLE 1. The TWINSPAN classification of species : the ground flora species in each of the seven groups generated at the third division level (see Figure 3) are listed, further sub-divided into fourteen groups at the fifth division level. The numbers in brackets after each species are those TWINSPAN *plot groups* for which the species was 'selective' (i.e. the TWINSPAN plot groups in Appendix 3 : Table 1 for which the frequency of the species is bolded – selective species were those whose frequency in the TWINSPAN group was significantly greater (χ^2 goodness of fit, $p < 0.01$) than in all of the 1200 Inventory plots taken together.) The TWINSPAN plot groups are listed below after each species in order of descending χ^2 value : for numbers not followed by an asterisque, χ^2 was significant at $p < 0.001$, for those followed by an asterisque, at $p < 0.01$.

SPECIES GROUP I

Alnus rugosa (3, 12)
Aster umbellatus (3)
Ilex verticillata (12, 3)
Osmunda claytoniana
Prunella vulgaris
Ptilidium pulcherrimun (3)
Rosa virginiana (3)
Rubus allegheniensis

SPECIES GROUP II

II A

Aster puniceus (3)
Circaea alpina (3)
Cirsium arvense
Dryopteris cristata (12, 3)
Epilobium angustifolium (3)
Equisetum arvense (3)
Equisetum sylvaticum (3)
Fragaria virginiana (3)
Galium triflorum (3)
Hieracium floribundum
Lonicera canadensis (3)
Lycopus uniflorus (3)
Osmunda cinnamomea (3, 12)
Ranunculus acris
Ranunculus repens (3)
Rhytiadelphus triquetrus (3)
Ribes glandulosum (3)
Rubus pubescens (3, 12*)
Solidago graminifolia
Taraxacum officinale
Typha latifolia (3)

II B

Aster lateriflora
Athyrium filix-femina (3)
Caltha palustris (3)
Cornus stolonifera (3)
Eupatorium maculatum (3)
Galium palustre (3)
Gymnocarpium dryopteris (3)
Impatiens capensis (3)
Mitella nuda (3)
Mnium spp. (3)
Onoclea sensibilis (3)
Prunus virginiana (3)
Ribes hirtellum (3)
Ribes lacustre (3)
Solidago macrophylla
Streptopus amplexifolius
Thalictrum polygamum (3)
Thelypteris palustris
Thelypteris phegopteris (3)
Trillium cernuum
Vicia cracca
Viola renifolia

II C

Corylus cornuta (3)
Acer spicatum (5, 3*)
Prenanthes altissima
Taxus canadensis (5, 3)

SPECIES GROUP III

III A

Actaea rubra
Cornus alternifolia (6)
Drypopteris spinulosa (5, 6)
Oxalis montana (5)
Sambucus pubens (6*)
Streptopus roseus
Thelypteris noveboracenis
Viola cucullata
Viola pallens (3, 6)

III B

Dennstaedtia punctilobula (7)
Lycopodium annotinum (7)
Lycopodium flabelliforme
Lycopodium lucidulum (7)
Lycopodium obscurum (7)
Medeola virginiana (7)
Smilacina racemosa (7, 6)
Trillium undulatum (6, 7)
Viola incognita (6, 7*)

III C

Aralia nudicaulis (6, 8)
Hieracium scabrum
Monotropa uniflora (7)
Prenanthes trifoliolata
Rhamnus alnifolia
Rubus canadensis (6)
Rubus strigosus
Viola septentrionalis

SPECIES GROUP IV

Aster acuminatus (6)
Polytrichum juniperinum
Pyrola elliptica
Trientalis borealis (6, 7, 8*)

SPECIES GROUP V

Achillea millefolium
Chimaphila umbellata
Clintonia borealis (8, 6)
Coptis groenlandica (8, 12, 3)
Dicranum scoparium (11, 8)
Luzula multiflora
Lycopodium clavatum (8*)
Maianthemum canadense (8, 9, 7*, 6*)
Sorbus americana (6, 8*)

SPECIES GROUP VI

VI A

Hieracium aurantiacum (10)
Hieracium canadense (10*)
Lycopodium tristachyum
Polytrichum commune (10, 9)
Veronica officinalis (10)

VI B

Amelanchier spp. (9, 8*)
Bazzania trilobata (8)
Cornus canadensis (9, 8)
Cypripedium acaule (13)
Hylocomium splendens (12, 8)
Linnaea borealis (8, 9)
Pteridium aquilinum (9, 14)
Virburnum cassinoides (8, 9, 14*)

VI C

Comptonia peregrina
Dicranum polysetum(14, 8, 10*)
Epigaea repens (14, 9)
Melampyrum lineare (14*)
Myrica pensylvanica (10)
Pleurozium schreberi (10, 8, 9, 14)
Ptilium crista-castrensis (10, 14)
Vaccinium angustifolium (14, 9, 10*)
Vaccinium myrtilloides (9, 14, 13)

SPECIES GROUP VII

VII A

Chamaedaphne calyculata (13)
Cladina rangiferina (14)
Cladina stellaris (14)
Gaultheria procumbens (14)
Gaylussacia baccata (13, 14)
Kalmia angustifolia (14, 9, 13, 12)
Ledum groenlandicum (14, 13)
Nemopanthus mucronata (13, 8, 12)
Rhododendron canadense (14)

VII B

Gaultheria hispidula (13)
Smilacina trifolia (12, 13)
Sphagnum spp. (13, 12, 3, 14)

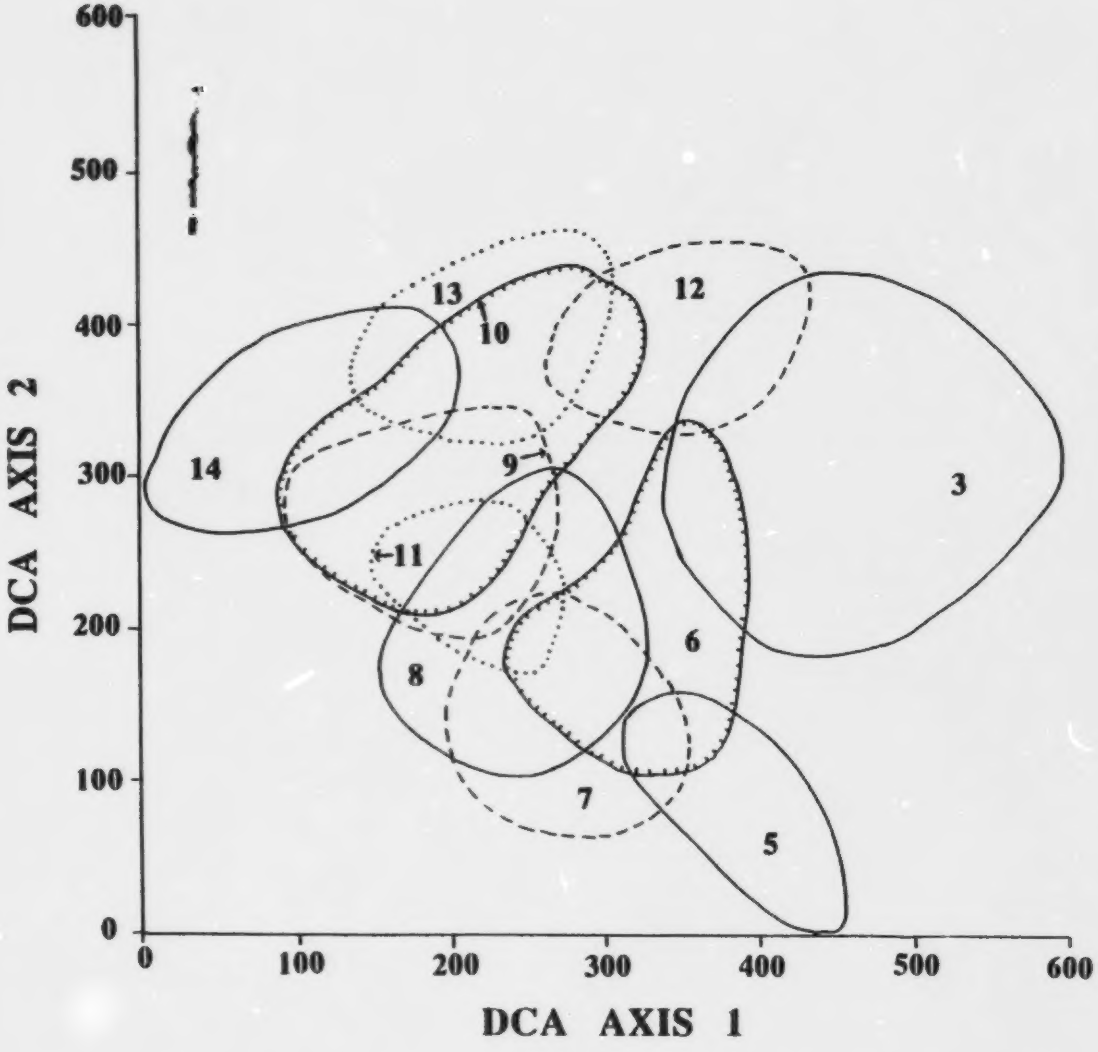

FIGURE 4. DECORANA ordination (along the first and second axes) of 1127 of the 4 m^2 ground flora plots assessed in the 1991 Prince Edward Island Forest Inventory. The main cluster of plots for each of the eleven principal TWINSPAN groups is contained within the boundary lines indicated - the positions of the individual plots for each TWINSPAN group are shown in Appendix 4.

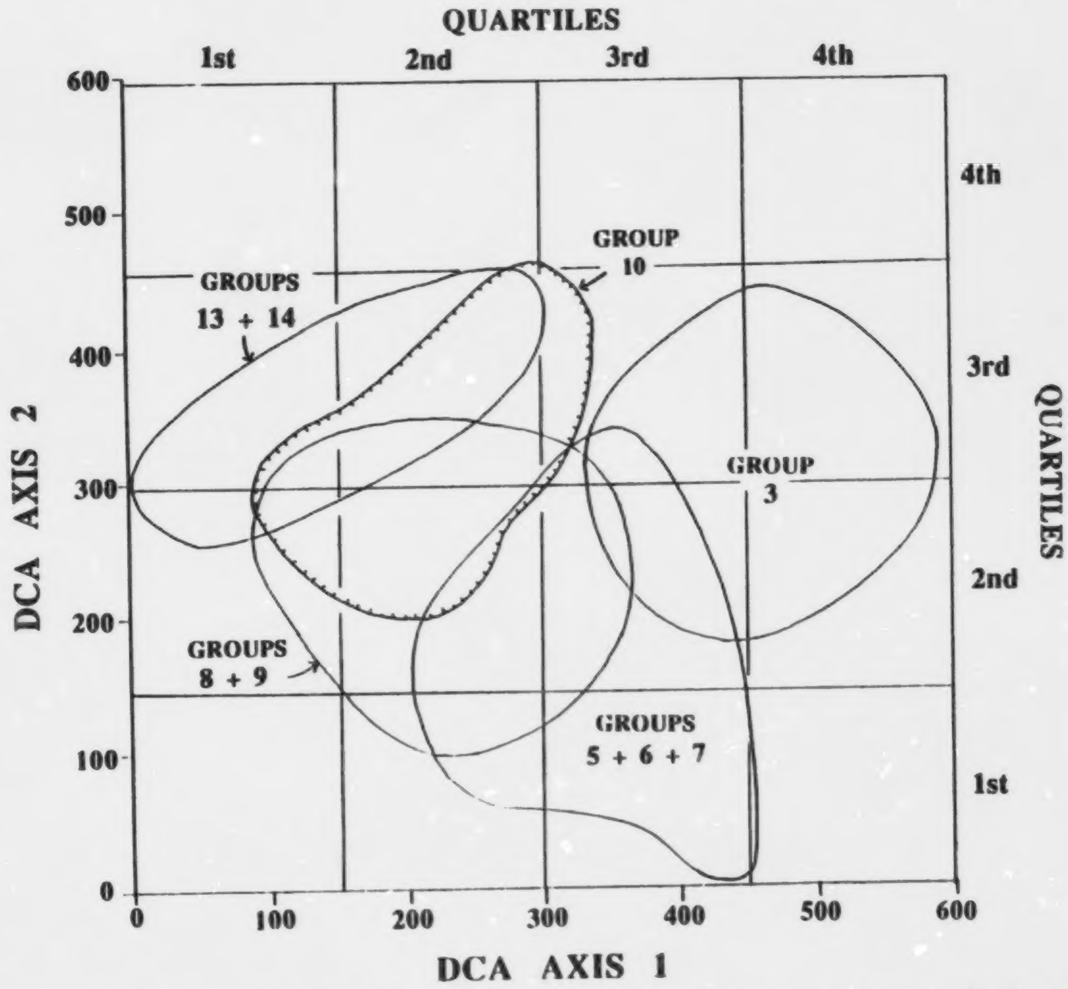

FIGURE 5. DECORANA ordination (along the first and second axes) showing the positions of the main cluster of plots for the TWINSPAN groups comprising the five major forest vegetation-types - these are : wet species-rich deciduous woodland (TWINSPAN Group 3) ; dry hardwood forest (Groups 5, 6 and 7); disturbed conifer-dominated forest (Groups 8 and 9); old field white spruce woods (Group 10); and black spruce - dominated forest (Groups 13 and 14). (The two axes have been sub-divided into four quartiles to facilitate χ^2 tests of association for the qualitatively-categorised attributes of the plots - see Tables 3 to 6.)

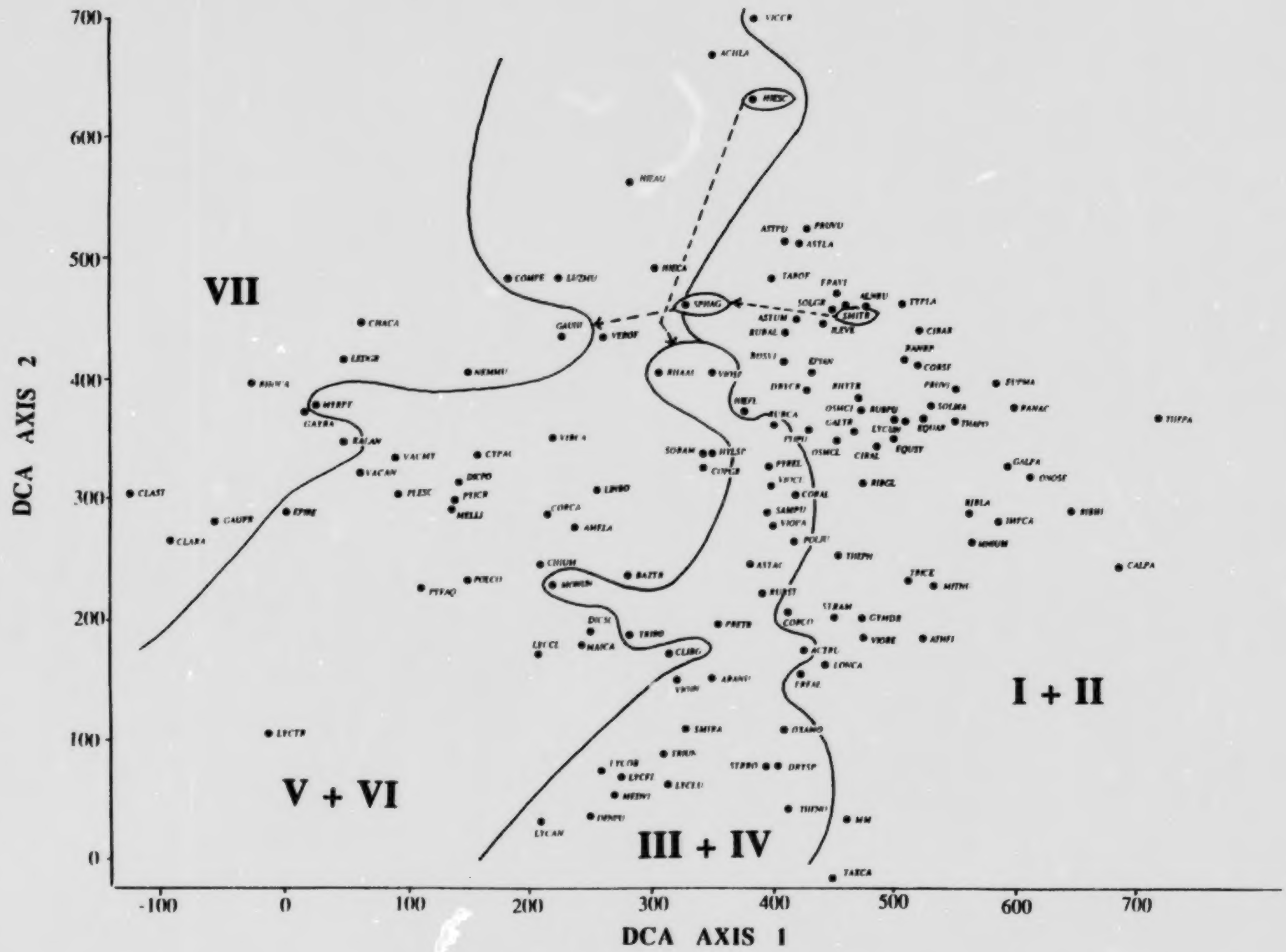

FIGURE 6. DECORANA ordination (along the first and second axes) of 128 of the ground flora species recorded in the 4 m^2 ground flora plots assessed in the 1991 Prince Edward Island Forest Inventory. The position of each species is indicated by a dot - the boundary lines separate the principal TWINSPAN Species Groups. (The species are identified by codes consisting of the first three letters of the generic name plus the first two letters of the specific name - these are listed in Appendix 7.)

The absence of factors of over-riding significance in the correlation analysis is probably due to the fact that the two groups of environmental factors likely to be of greatest importance in determining vegetation differences could not be assessed using the Pearson correlation coefficient because they had been measured qualitatively rather than quantitatively – i.e. soil drainage, and the extent of human disturbance. Therefore, for these, as well as for the other qualitatively determined variables, a different approach had to be used to assess their relation to the ordination : χ^2 tests (Tables 3, 4, 5 and 6) were carried out to assess whether there was any association between the sub-classes of the qualitative attributes, and the position of the plots along the first two DECORANA axes – when the axes were divided into four equal quartiles (see Figure 5).

Here the results prove to be more easily interpretable ecologically than were the soil and topographical correlations : although the total χ^2 values for the various attributes cannot be compared directly because of differing degrees of freedom, it is evident that for all but one of the attributes (stand age) there were indeed significant and high levels of association between the subclasses and their distribution along each of the axes. This is especially evident for the assessments of those factors related to soil moisture levels (Tables 3 and 4) : features connected with or indicating high soil moisture levels (i.e. level ground, organic soils, a high water table, poor and imperfect drainage (as determined in the field Inventory), poorly and imperfectly-drained soil series – were all positively associated with the upper ends of each of the two axes (Figure 5) – i.e. the region occupied by Group 3 on the first axis, and by Groups 12 and 13, and parts of Groups 3, 14 and 10 on the second axis. Conversely, the attributes indicative of low soil moisture levels (sloping ground, well-drained soils, well-drained soil series, soil compaction (i.e. the absence of a high water table)) were mostly negatively associated with this region of each of the axes, and were instead positively associated with other regions. Many of these attribute classes have already been found to be significantly associated with particular TWINSPAN groups in a way that is consistent with the overall pattern emerging here (see Appendix 3 : Tables 3-13, 3-18) – what the ordination is further indicating is that there is an *overall* spatial pattern to these factors among all of the plots taken together. This suggests that these factors are likely to be of over-riding significance in determining the distribution of the plant species.

When we turn to the forest stand properties of the sites (Tables 5 and 6) we find that with the exception of stand age, all of the attributes were significantly associated with the distribution of the plots along each of the axes – and, as has just been noted for the soil properties, the associations found to be significant (listed in Tables 5 and 6) correspond to the properties of the TWINSPAN groups occurring in those quartiles (see Appendix 3 : Tables 3-12, 3-20). Especially important as an indicator of possible causal factors acting on the ground flora groups are the attributes 'Stand history' and 'Status 1935' – concerned as they are with the past history (including recent management and/or disturbance at the sites).[2] These showed a higher level of association with the second axis : along that axis, stands recorded as 'old field' occurred much more frequently than expected due to chance in the combined third and fourth quartile (i.e. the part of the axis occupied by Groups 12 and 13, and parts of Groups 3, 10, and 14). By contrast, the first quartile – in which the apparently least human-disturbed of all of the ground flora groups occurs (Group 5 – see Appendices 1 and 3) – was positively associated with 'nothing evident' and 'burn'.[3] As was so for the soil properties, the importance of the significant associations evident in Tables 5 and 6 , is that it indicates that there is an *overall* spatial pattern to these forest stand attributes among the groups, and that these suggest an over-riding trend affecting the general distribution of plant communities.

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[2] So also 'Stand origin/history' – but this attribute includes two classes ('swampy' and 'bog') which are measures of *innate* site properties (in particular, soil drainage) – since these contributed a high proportion of the total χ^2 value, a different attribute 'Stand history' which omitted these two classes was created and examined.

[3] The Inventory results for the 'burn' category present a problem : it showed a significant association with the hardwood stands, especially Groups 5 and 7 (see Table 3-12) – a forest-type that does not carry fire except under very unusual circumstances. J. D. McAskill (pers. comm.) suggests that the higher frequency of 'burn' in the hardwood stands may be due to the burning connected with past land clearing. The field crews say they used the code whenever they found charcoal in the soil pit or trees that were fire-scarred – the latter very infrequently.

TABLE 2. The correlation of the quantitatively measured environmental variables (Pearson's correlation coefficient) with the plot scores on the first four axes of the DECORANA ordination.[1]

		AXIS 1	AXIS 2	AXIS 3	AXIS 4
EIGENVALUES[2]		0.65	0.51	0.44	0.37
Topographical Factors					
Elevation		-0.08**	-0.24***	0.26***	0.10***
Slope		ns	0.14***	0.21***	0.16***
Distance to coast		-0.10***	-0.22***	0.18***	ns
Distance to road		ns	0.18***	-0.10***	ns
Corn heat units		0.13***	0.19***	0.31***	0.14***
Tree Canopy Properties					
Tree age		ns	ns	ns	ns
Tree height		ns	ns	0.08**	ns
Actual density		ns	ns	0.07*	0.05*
Soil Field Properties					
A-horizon thickness		ns	ns	ns	ns
Rooting depth		-.07**	ns	ns	ns
Soil Chemical Properties					
pH	(H)	ns	0.14***	-0.16***	-0.07*
	(B)	0.09**	0.18***	-0.18***	-0.09***
% Carbon	(H)	-0.09***	ns	-0.16***	-0.16***
	(B)	-0.05*	-0.07**	ns	ns
Macronutrients:					
Nitrogen	(H)	ns	ns	-0.10***	-0.10***
	(B)	ns	-0.12***	ns	ns
Phosphorus	(H)	-0.16***	-0.20***	ns	-0.08**
	(B)	ns	-0.06*	0.12***	0.11***
Sulphur	(H)	ns	ns	-0.08**	ns
	(B)	ns	-0.09**	ns	ns
Potassium	(H)	-0.24***	-0.21***	-0.07*	-0.20***
	(B)	ns	ns	ns	ns
Calcium	(H)	0.10***	0.21***	-0.15***	ns
	(B)	0.13***	0.21***	-0.10***	ns
Magnesium	(H)	-0.08**	ns	ns	-0.08**
	(B)	ns	0.09**	-0.12***	-0.05*
Micronutrients					
Boron	(H)	0.07*	0.07**	ns	ns
	(B)	ns	-0.07*	ns	ns
Copper	(H)	-0.06*	ns	ns	ns
	(B)	ns	ns	0.06*	ns
Iron	(H)	0.16***	0.15***	0.17***	0.20***
	(B)	ns	ns	ns	ns
Manganese	(H)	-0.10***	ns	-0.08**	ns
	(B)	0.09**	0.23***	-0.13***	ns
Zinc	(H)	-0.13***	-0.06*	ns	-0.08**
	(B)	ns	ns	0.07*	ns

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1. Degrees of freedom – varies between 1149 and 1198.
   Probabilities : *** – $p < 0.001$; ** – $p < 0.01$; * – $p < 0.05$; ns – not significant.

2. The eigenvalue for each axis is a measure of the variance accounted for by that axis.

TABLE 3. χ^2 analysis of the association between the qualitatively-categorized soil properties of the plots and the position of the plots along the **first** DECORANA axis - when subdivided into four equal quartiles (see Figure 5). For each attribute those individual classes whose χ^2 contributed significantly (d.f. = 1) to the total χ^2 value are listed, the [+] or [-] after each class indicating the nature of the association. (The soil textures have been grouped as shown in Appendix 3: Table 13 ; the drainage class for each soil series is given in brackets: r - rapidly drained; w - well drained; i - imperfectly drained; p - poorly drained.)

ATTRIBUTE	1st QUARTILE	2nd QUARTILE	3rd QUARTILE	4th QUARTILE
Soil texture $\chi^2 = 161.2$ *** (d.f. = 15)	Moderately coarse [+] ** Coarse [+] *	Medium [+] * Coarse [-] ***		Fine [+] *** Medium [-] *** Coarse [+] *** Organic [+] **
Soil drainage $\chi^2 = 175.8$ *** (d.f. = 9)		Well [+] * Poor [-] ***	Moderately -well [-] *	Well [-] *** Mod.-well [+] ** Imperfectly [+] * Poor [+] ***
Soil series $\chi^2 = 260.0$ *** (d.f. = 39)	Culloden (r) [+] *** Charlottetown (w) [-]** Orwell (p) [+] *	Rocky Point (p) [-] ** Stream complex (p) [-] *	Culloden (r) [-] *** Charlottetown (w) [+] **	Culloden (r) [-] ** Alberry (w) [-] *** Charlottetown (w) [-] *** Rocky Point (p) [+] *** Duvar (i) [+] * Malpeque (i) [+] * Baptist Point (p) [+] ** Mossy Point (p) [+] ** Winsloe (p) [+] ***
Soil series (grouped by drainage class) $\chi^2 = 178.7$ *** (d.f. = 9)	Rapidly-drained [+] *** Well+moderately drained [-] **	Poorly drained [-] **	Rapidly-drained [-] *** Well+moderately drained [+]*	Rapidly-drained [-] ** Well+moderately drained [-] *** Imperfectly drained [+] ** Poorly drained [+] ***
Root restriction $\chi^2 = 119.9$ *** (d.f. = 3)		Water table [-] ***		Water table [+] *** Compaction [-] *
Slope $\chi^2 = 46.9$ *** (d.f. = 3)				Sloping [-] *** Level [+] ***

Probabilities: *** - $p < 0.001$
** - $p < 0.01$
* - $p < 0.05$
ns - not significant

TABLE 4. χ^2 analysis of the association between the qualitatively-categorized soil properties of the plots and the position of the plots along the **second** DECORANA axis - when subdivided into four equal quartiles (see Figure 5). (In the analysis, the plots in the third and fourth quartiles had to be combined because of the small number of plots in the fourth quartile.) For each attribute those individual classes whose χ^2 contributed significantly (d.f. = 1) to the total χ^2 value are listed, the [+] or [-] after each class indicating the nature of the association. (The soil textures have been grouped as shown in Appendix 3, Table 13; the drainage class for each soil series is given in brackets : w - well drained; i - imperfectly drained; p - poorly drained; 'remaining series' refers to those soil series, each occurring in fewer than 20 of the 1127 plots, all combined as a residual group in the χ^2 analysis.

ATTRIBUTE	1st QUARTILE	2nd QUARTILE	3rd + 4th QUARTILES
Soil texture $\chi^2 = 144.2$ *** (d.f. = 10)	Fine [-] ** Medium [+] *** Coarse [-] * Organic [-] *	Organic [-] **	Fine [+] ** Medium [-] *** Coarse [+] *** Organic [+] ***
Soil drainage $\chi^2 = 245.3$ *** (d.f. = 6)	Well [+] *** Mod.-well [-] ** Imperfectly [-] ** Poor [-] ***	Poor [-] ***	Well [-] *** Imperfectly [+] *** Poor [+] ***
Soil series $\chi^2 = 202.1$ *** (d.f. = 26)	Alberry (w) [+] ** Charlottetown (w) [+] *** Margate (i) [-] * Orwell (p) [-] * Rocky Point (p) [-] * Winsloe (p) [-] *		Alberry (w) [-] *** Charlottetown (w) [-] *** Duvar (i) [+] * Baptist Point (p) [+] *** Margate (i) [+] * Mossy Point (p) [+] * Orwell (p) [+] *** Rocky Point (p) [+] *** Winsloe (p) [+] ** Remaining series [+] *
Soil series (grouped by drainage class) $\chi^2 = 181.8$ *** (d.f. = 6)	Well + moderately drained [+] *** Imperfectly drained [-] * Poorly drained [-] ***	Poorly drained [-] *	Well + moderately drained [-] *** Imperfectly drained [+] ** Poorly drained [+] ***
Root restriction $\chi^2 = 82.1$ *** (d.f. = 2)	Water table [-] ***	Water table [-] **	Water table [+] ***
Slope $\chi^2 = 93.1$ *** (d.f = 2)	Sloping [+] ** Level [-] ***		Sloping [-] *** Level [+] ***

Probabilities: *** - $p < 0.001$
** - $p < 0.01$
* - $p < 0.05$
ns - not significance

TABLE 5. χ^2 analysis of the association between the qualitatively-categorized forest stand properties of the plots and the position of the plots along the **first** DECORANA axis - when subdivided into four equal quartiles (see Figure 5). For each attribute those individual classes whose χ^2 contributed significantly (d.f. = 1) to the total χ^2 value are listed, the [+] or [-] after each class indicating the nature of the association. (For further details on the classes, see the main text, and Appendix 3: Tables 12 and 20.)

ATTRIBUTE	1st QUARTILE	2nd QUARTILE	3rd QUARTILE	4th QUARTILE
Geographical region χ^2 = 145.6 *** (d.f = 6)	West [-] ** Central [-] *** East [+] ***		Central [+] *** East [-] ***	West [+] *** Central [-] * East [-] **
Forest size χ^2 = 50.6 *** (d.f. = 6)	<5 [-] ** ≥ 10 [+] ***	≥5 [-] *	≥5 [+] * ≥10 [-] **	
Forest type χ^2 = 197.4 *** (d.f. = 12)	SS [+] *** SH [+] * HS [-] ** HH [-] ***		SS [-] *** SH [-] * HH [+] ***	
Stand age χ^2 = 11.4 ns (d.f. = 6)				
Stocking class χ^2 = 77.1 *** (d.f. = 9)	2 [+] *	1 [-] * 2 [-] **		1 [+] *** 2 [+] *** 4 [-] ***
Stand origin/history χ^2 = 67.9 *** (d.f. 18)		Swampy [-] **		Swampy [+] ***
Stand history[1] χ^2 = 22.3 * (d.f. = 12)				Nothing evident [-] *
Status 1935 χ^2 = 37.4 *** (d.f. = 3)	Cleared [+] ***		Cleared [-] **	
Status 1935 + evident origin[2] χ^2 = 19.4 *** (d.f. = 3)	Cleared [+] *		Cleared [-] *	

1. The attribute 'Stand history' was derived from the 'Stand origin/history' attribute by omitting the two classes determined by innate site properties and not by historical events (i.e. the 'swampy' and 'bog' classes).

2. The attribute 'Status 1935 + evident origin' is derived from two separate sources of information on the 'old field' status of the plots: the 1935 aerial photographic analysis, and the 1991 Inventory. For this attribute there were two classes of plots: 'Cleared land' - either land clear of forest in 1935 and/or classed as 'old field' in the 1991 Inventory; Forest cover - i.e. covered by forest in 1935, and not recorded as 'old field' in the Inventory.

Probabilities: *** - $p < 0.001$, ** - $p < 0.01$, * - $p < 0.05$, ns - not significant

TABLE 6. χ^2 analysis of the association between the qualitatively-categorized forest stand properties of the plots and the position of the plots along the **second** DECORANA axis - when subdivided into four equal quartiles (see Figure 5). (In the analysis, the plots in the third and fourth quartiles had to be combined because of the small number of plots in the fourth quartile.) For each attribute those individual classes whose χ^2 contributed significantly (d.f. = 1) to the total χ^2 value are listed, the [+] or [-] after each class indicating the nature of the association. (For further details on the classes, see the main text, and Appendix 3: Tables 12 and 20.)

ATTRIBUTE	1st QUARTILE	2nd QUARTILE	3rd + 4th QUARTILES
Geographical region $\chi^2 = 56.8$ *** (d.f. = 4)	West [-] ** Central [+] *** East [-] *		West [+] ** Central [-] ***
Forest size $\chi^2 = 45.1$ *** (d.f. = 4)	≥5 [+] *** ≥10 [-] ***		<5 [-] * ≥10 [+] **
Forest type $\chi^2 = 308.5$ *** (d.f. = 8)	SS [-] *** SH [-] *** HS [-] * HH [+] ***	SS [-] * SH [+] * HS [+] * HH [-] *	SS [+] *** HH [-] ***
Stand age $\chi^2 = 9.5$ * (d.f. = 4)			
Stocking class $\chi^2 = 156.0$ *** (d.f. = 6)	2 [-] *** 3 [-] *** 4 [+] ***	2[-]*	1 [+] *** 2 [+] *** 3 [+] ** 4 [-] ***
Stand origin/history $\chi^2 = 214.8$ *** (d.f. = 12)	Old field [-] *** Burn [+] *** Swampy [-] ** Nothing evident [+] ***	Partial cut [+] * Swampy [-] ***	Old field [+] *** Partial cut [-] *** Burn [-] * Swampy [+] *** Bogy [+] *** Nothing evident [-] *
Stand history[1] $\chi^2 = 122.0$ *** (d.f. = 12)	Old field [-] *** Burn [+] *** Nothing evident [+] **		Old field [+] *** Burn [-] * Partial cut [-] *
Status 1935 $\chi^2 = 60.3$ *** (d.f. = 2)	Cleared [-] *** Forested [+] *		Cleared [+] *** Forested [-] **
Status 1935 + evident origin[2] $\chi^2 = 72.6$ *** (d.f. = 2)	Cleared [-] *** Forested [+] ***		Cleared [+] *** Forested [-] **

1 and 2. See equivalent footnotes of Table 5

Probabilities:
*** - $p < 0.001$
** - $p < 0.01$
* - $p < 0.05$
ns - not significant

The analysis of the qualitative attributes has thus indicated that the assessments relating to soil moisture levels and to past history are significantly associated with the overall distribution of the plots in the first two dimensions of the ordination space – this suggests that they are likely to play a significant role in determining the ground flora species make-up of the plots. Whereas the soil moisture factors seem to be equally important along both axes, the considerably greater χ^2 values for past history attributes on the second axis compared with the first, suggest that it is of greater importance in distinguishing the plots along this axis. Unfortunately, because of the different statistical procedures used in their assessment, we are not able to directly compare in a single comparative ranking the importance of the qualitative variables with that of the quantitative ones. However, it should be noted that the comparatively high level of significance of the topographical factors along the second axis (notably, the negative correlation of elevation and distance to the coast) is consistent with the results of the χ^2 association analysis for the soil moisture properties – though slope and corn heat units (despite their positive correlations with elevation and distance to the coast – see Appendix 6) do not show the same trend.

DISCUSSION

For the first time in the botanical history of Prince Edward Island we have a *quantitative* record of the woodland plant community-types occurring on the Island. What is more, this is based on a very large *objectively-selected* sample which has been analysed using entirely *objective* techniques of classification and ordination.

As a result of the Inventory we are now able to define the major forest-types of Prince Edward Island at the end of the twentieth century : the TWINSPAN classification has resulted in the recognition of eleven ground flora groups which can be combined as five main forest vegetation-types, some of these with sub-types. And because of the large amount of data of various kinds collected in the Inventory we are able to describe each of the groups in considerable detail – not only in terms of their ground flora, but also their tree and shrub components (including the small regenerating trees). We also have a large amount of information on the forest stand properties and on the topographical, soil and historical/management factors operating on each of them.

We also have information on the factors that are responsible for the general variation in the Island's forest vegetation : the DECORANA ordination indicates that of all the environmental factors assessed, two – soil moisture levels and forest disturbance – appear to be especially important in overall terms in determining the forest-types – it is they (and especially moisture levels) that show a high degree of association with the position of the plots along the first two ordination axes. And the importance of these two factors was also borne out by the analysis of the properties of the TWINSPAN groups (Appendix 2) : differing soil moisture levels are a key factor distinquishing some of the TWINSPAN groups, while the importance of the human factor is evident throughout the analysis : all of the ground flora groups had a varying proportion of plots which had been subjected to various types of human intervention (Table 3-12); and it was human activity *per se* that is the most obvious factor accounting for some of the groups – especially some of the conifer-dominated ones (i.e. Groups 8, 9 and 10); it also appears to be differing degrees of human-disturbance that differentiates the three hardwood groups.

How do these findings compare with previous descriptions of the forest vegetation of Prince Edward Island ? Apart from those works that are too general to be of specific applicability to the Island – except in placing its forests in the context of regional or continental vegetation-types (i.e. Halliday 1937, Loucks 1961, Rowe 1972 [4]), there are only two studies which touch in any detail on the forest vegetation of the Island – in both, as a peripheral aspect to their main line of study : Erskine's (1960, 1985) *Plants of Prince Edward Island* and MacDougall *et al.*'s (1988) *Soils of Prince Edward Island*. Like this study, both considered that soil drainage was especially important in determining the type of forest occurring in particular areas, but they also recognized the very important effects of human disturbance.

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[4] Halliday (1937), in a study of Canadian forests included the Island's forests in his Acadian Forest Region – more specifically in the region's Central Section (which also comprised most of southern New Brunswick and northern mainland Nova Scotia). Loucks (1961) in a study of Maritime forests, sub-divided Prince Edward Island into three geographical *cum* forest-type 'districts' : one comprising the areas dominated by hardwood forests; and two coniferous forest districts, one west of Summerside along the shores of Northumberland Strait, the other in the east on sandy soils along the Gulf of St. Lawrence. But neither of these studies looked in any detail at the variation of the forests within the Island itself.

The Inventory now provides quantitative data to back-up these previous speculations : on an island in which there is a very limited range of soil parent materials (most are derived from sandstone and similar rocks (MacDougall *et al.* 1988)) and of climatic variation, the principal innate factor responsible for the variation in the forest vegetation are variations in soil drainage. Drainage in turn is determined by a combination of topographic factors (key factors in this respect are slope and elevation), and the nature of the soil parent material. Superimposed on any differences caused by drainage are the effects of three centuries of human interference – involving the initial forest clearance for the creation of farmland, followed by the continual exploitation of the remaining forest stands for timber and firewood, and in this century especially, the abandonment of some of the poorer farmland, resulting in its recolonisation in a process of secondary forest succession (see Clark (1959) for a history of land usage including forest clearance and farm abandonment, and McAskill (1987) for a summary history of forest exploitation).

That the information that has emerged from this study is in agreement with the observations of the few previous workers who have had an interest in the Island's forests is especially pleasing in view of the small plot size used in the Inventory for the assessment of the ground flora (4 m^2) – a size imposed by financial constraints. (Usually much larger plot sizes (e.g. 200 m^2 (Bunce 1982) or 450 m^2 (Zelazny *et al*. 1989)) are used in forest studies.) Even though the 4 m^2 plot has been shown (Sobey 1993) to have picked up on average only a third of the ground flora species in the *c*. 1000 m^2 area around a sampling point, this has not prevented statistically-distinctive ground flora groups from emerging in the multivariate analyses. Furthermore, as indicated in the discussions of Appendix 2, these groups have proved for the most part to be recognizable in the field as distinct vegetation-types. They are also consistent with previous information on the forest vegetation of the Island, as well as amenable to logical explanation in terms of environmental and historical factors. Undoubtedly a larger plot size, if combined (as is usual in such studies) with the omission in the field of those sites that were obviously heterogeneous, might have led to the production of ground flora groups that were more distinctive and discrete – with for example the plots showing less overlap in the DECORANA ordination (Figure 4, see also Appendix 4), but this would also have masked an important feature of Island forests (or any forest for that matter) : forest vegetation is likely to be continuously variable in the composition of both its tree canopy and ground flora. In fact, a larger plot size, *without* the simultaneous elimination of sample plots containing obviously diverse vegetation-types, would probably have lead to less distinction between the groups. And since any process of eliminating plots would have inevitably involved questionable subjective decisions, a small plot size has thus had benefits – an additional one being that a much larger *number* of plots were able to be recorded within the limits imposed by the financial constraints.

It should however be noted that, just as the 1991 Inventory did not pick up many of the rarer plant species (Sobey 1993), so it is possible that any forest vegetation-type with a limited distribution may also not have been picked up at the 240 sampling sites, or at least not in sufficient numbers to constitute a recognizable group in the analysis. With reference to Erskine (1960) and to New Brunswick studies (e.g. Zelazny *et al.* 1989), some woodland types that might constitute distinct plant community-types on the Island, but which have not emerged in the analysis are : cedar woods – only 40 sites in all contained cedar – most of these were classified in the wet deciduous woodland group (Group 3); the richer variant of the fern-herb forest (i.e. stands equivalent to the Richmond Ash Natural Area or the Haliburton Ironwoods (Anon. 1982, Sobey 1993), and pine woods (i.e. stand equivalent to the Brudenell Pines Natural Area, or the Canovy Pines candidate natural area (Anon. 1982, Sobey 1993)). To obtain a sufficiently sized sample of such rare woodland types we would probably need to actively search for and then sample such sites in a selective separate inventory.

ADDENDUM : SOME FURTHER DISCUSSION POINTS

I now wish to consider some further points arising from the plant community analysis of the 1991 Inventory data. None of these points will be fully explored here – rather the discussion will give an indication of the applications to which the data might be put, and indicate some lines of future research.

APPLYING THE RESULTS BEYOND THE 1200 SAMPLE POINTS

A first question concerns the extent to which we can apply the results of the analyses beyond the 1200 sampling points – an early stage in this respect is to try to work out the proportion of the Island's forested area occupied by each of the forest-types. We might initially think that we could estimate this directly from the results of the TWINSPAN analysis – for example, 38% of the plots (428 of 1127) were classified in Groups 5, 6 and 7 (the dry hardwood forest groups) – we might think that this should mean that such forests comprise 38% of the Island's present woodland. But this is not so – this is because the method of sampling, although totally objective, required that if a kilometre square that had been selected randomly was to be used in the Inventory, it had only to contain (or overlap) a wooded area large enough to hold the 400 metre long cruise line – avoiding edge effects, that means any woodlot having one linear dimension of at least 600 metres. There are many small woodlots (even in the intensively agricultural parts of the province) that meet this criterion, with the result that the 240 sample sites are fairly even distributed over the whole Island – regardless of the extent to which any area is wooded in overall terms (see Figure 1). Thus, the number of sampling sites falling in each of the three regions of the Island is in direct proportion to the region's *total* land area and not to the size of its *forested* area (Table 7), with the comparatively lightly-forested central region being as intensively sampled as the more heavily-forested eastern and western regions.

This means that although the sampling has given a representative and balanced picture of the woodland in all parts of the Island, we cannot directly extrapolate the percentages of plots in each TWINSPAN group to the total wooded *surface area* of the Island. Rather, it would be more correct to say (using the hardwood example above) that 38% of *wooded parcels* (or woodlots) are of hardwood type – but because hardwood parcels tend on average to be smaller than conifer parcels (see Appendix 3: Table 3-20a, comparing the hardwood groups 6 and 7 with the conifer groups 8, 9 and 14) the *total land area* under hardwood groups will be less than 38%.

In any estimating of the land area occupied by each of the forest-types, other means will thus have to used. For those groups that have distinctive tree canopies one approach may be to use the analysis of aerial photography – along the lines discussed below.

MAPPING THE TWINSPAN GROUPS

The Inventory itself gives an indication of the spatial distribution of the various ground flora groups on the Island especially for the larger groups : the distinctive spatial patterns evident in the maps of Appendix 1 do not conflict with the limited information available before the 1991 Inventory (e.g. Erskine 1960) – in fact they greatly add to it. But is it possible, by adding information from other sources, to be even more precise in the mapping of the main forest vegetation-types of the Island ?

The most important additional source of information in this respect is provided by another element of the 1991 Forest Inventory : the August 1990 false colour infrared aerial photographic survey of the Island. Using the 1:17,500 scale photographs produced by the survey, photo-interpreters in the Forestry Branch have identified the major species present in the canopy of all forest stands on the Island, recording up to five species with percentage cover in the canopy greater than 5%. The results have been computerised and linked to the Geographic Information System (G.I.S.) for the province. Computer-generated maps for the more important tree canopy species have been published (Glen 1993) which show all of the forest stands in which each species contributed a minimum of 5% to the canopy (e.g. see Figure 7).

Because some of the TWINSPAN-derived vegetation-types are dominated by a particular tree species, these maps may be used as a starting point in constructing more comprehensive maps for these vegetation-types – 5% cover is likely to

TABLE 7. A comparison of the distribution of the sampling sites in relation to the total land area for the three geographical regions of the Island recognized in this study (see Figure 1). *

Region	Acres ‡ (x 1000)	% of Island	No. of sites (plots)	% of plots
Western	367	26.2	61 (305)	25.4
Central	425	30.4	80 (400)	33.3
Eastern	605	43.3	99 (495)	41.3

‡ The area of each region was calculated from the acreage of each lot (i.e. township) as adjusted by Clark (1959) pp. 260-61.

* A χ^2 goodness-of-fit (comparing the observed distribution of sites among the regions with that expected if the distribution was proportional to land area) : $\chi^2 = 0.96$ – not significant (df =2).

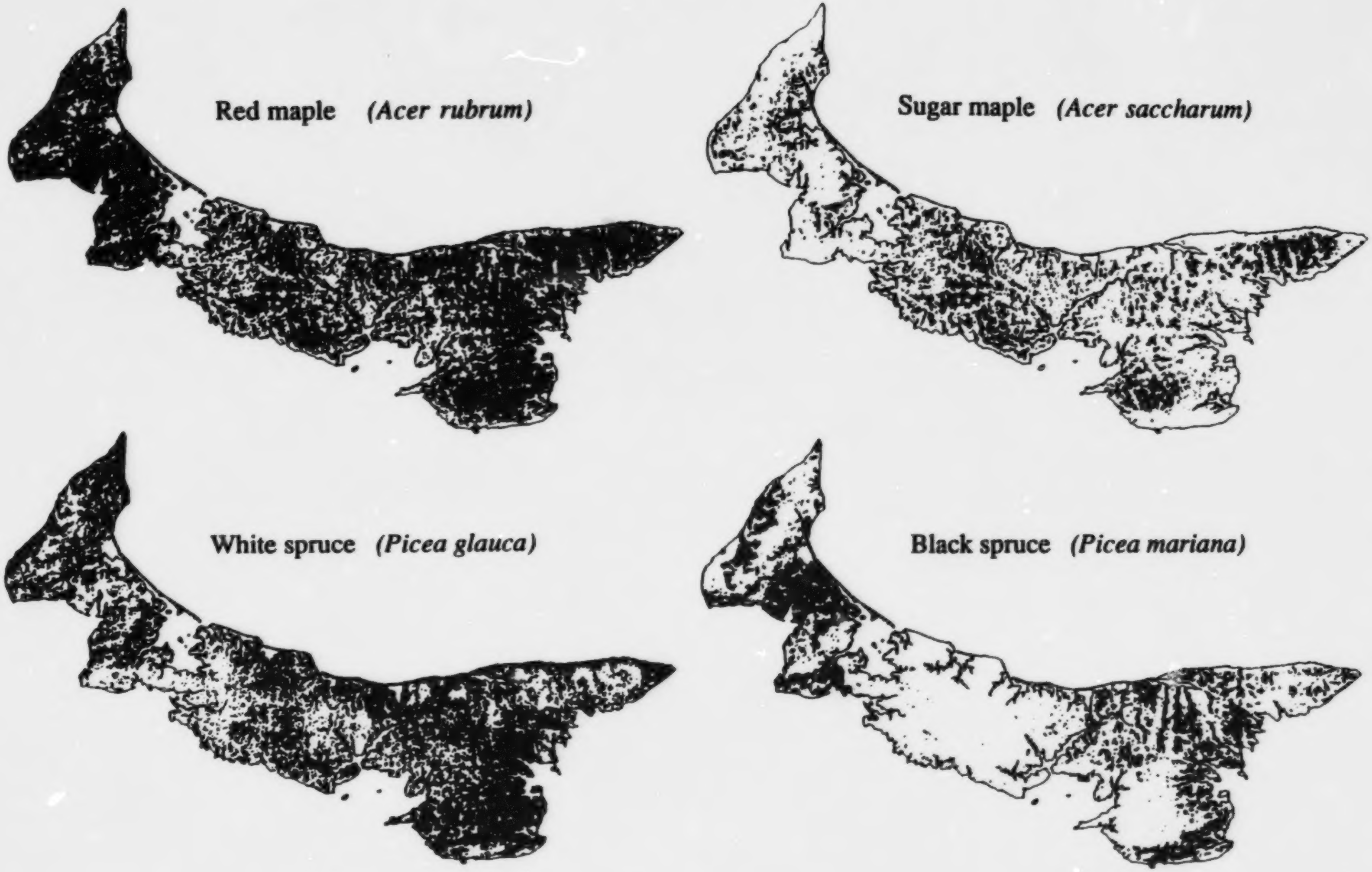
Red maple (Acer rubrum)
Sugar maple (Acer saccharum)
White spruce (Picea glauca)
Black spruce (Picea mariana)

FIGURE 7. Maps (from Glen 1993) showing the distribution on Prince Edward Island of all the forest stands in which particular tree species contributed a minimum of 5% to the tree canopy. The maps are based on photo-interpretation of the August 1990 false colour infra-red aerial photographic survey of the Island and were generated by computer, using the Geographic Information System for the province.

be too low for this purpose but percentages can be set at any value. In Appendix 2, where appropriate, I have made suggestions for the more comprehensive mapping of some of the vegetation-types on the Island. This approach has the advantage of using existing computer data-files – it might also lead to an estimate of the total land *area* under each vegetation-type.

THE TWINSPAN GROUPS AND THE SOIL SURVEY OF P.E.I.

Another possible aid in mapping the vegetation-types may be the soil survey maps of the province (MacDougall *et al.* 1988). The overall level of association between the TWINSPAN groups and the soil series types is striking (Tables 3-17 and 3-18) – this is all the more remarkable given that the 1:10,000 soil maps are not intended to be used in the site-specific way in which I have used them : rarely are the map units (i.e. the areas on the map designated as of a particular soil type) 100% pure, and inevitably subjective decisions must have been involved in the drawing of the boundaries on the maps. [5] In addition, there is always the possibility of the misclassification of ground flora plots by the TWINSPAN classification due to the chance absence of indicator species from plots of small size. But despite these limitations, not only do the soil series of the TWINSPAN groups, when grouped according to drainage (Tables 3-18b), show a close agreement with the drainage classes as assessed in the Inventory (compare Table 3-13), there are also statistically-significant associations (both positive and negative) between some of the TWINSPAN classes and particular soil series types. Thus, for example, the upland deciduous hardwood forest groups (5, 6, and 7) occur primarily on soil series that are well-drained, all three groups having significant positive associations with the Charlottetown series, while Group 5 also has a significant association with the Alberry series (Table 3-18a). By contrast Groups 3, 12, 13 and 14 have a high level of association with poorly-drained soil series (when these are grouped) (Table 3-18b), with some of the individual series being frequent enough to also show significant associations (Table 3-18a). (I suspect that the correlation between the TWINSPAN groups and the soil series would be a lot more clear-cut if instead of using the 1:10,000 maps, each of the 1200 plots had been individually classified as to its soil series type on the basis of its field properties.)

Given these significant associations, could the soil survey maps be used to aid in the mapping of the vegetation-types? The lack of an exclusive one-to-one association between any TWINSPAN group and a particular soil series (see Table 3-17) is a handicap here – it thus seems likely that the soil maps would not add much new information to that provided by the 1990 aerial photo analysis of the tree canopy. However, this is an area worthy of further investigation in future and I have thus made further comment in Appendix 2 on the use of the soil survey maps in the mapping of some of the TWINSPAN groups.

It should also be noted that the Inventory may provide useful information for any future soil survey. The descriptions in the 1988 soil survey, of the vegetation associated with the various soil series, although little more than lists of tree species, do indicate that particular soil series tend to be found under certain forest-types. However, the lack in the soil survey report of any quantitative information on the relative importance of the various tree species that are listed, and little if any on the ground flora species occurring, limits the value of the descriptions. In a future soil survey it may be possible to assign the vegetation at a soil sampling site to a particular TWINSPAN group – at it simplest, by using the indicator species listed in Figure 2, aided by the species lists in Appendix 3 : Table 3-1. And because for each of the groups, we have quantitative information on the relative importance of the various tree species, it may be possible to provide a more accurate and extensive description of not only the ground vegetation but also of the tree canopy associated with the various soil series.

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[5] The map units or polygons are considered by MacDougall *et al.* (1988) to be only 80% pure, with the dominant soil series making up as low as 65% of a map polygon bearing its name. There were also mixed polygons for which a second soil series was listed – which was ignored in compiling the data in Tables 3-17 and 3-18.

THE TWINSPAN GROUPS AND HISTORICAL STUDIES

Might we use the results of the multivariate analysis to attempt to construct an historical picture of the Island's forest vegetation – especially that prior to the beginning of European settlement ?

There are two aspects to such an historical reconstruction – the first is to *define* the forest-types before the period of European settlement – preferably in quantitative terms, and for *all* the plant strata including the ground flora; the second is to reconstruct their spatial distribution on the Island – i.e. to produce a map for each of the recognized forest-types.

In both of these tasks we are hampered by a considerable problem : we currently have little information on either of these aspects – the forests of this intensively settled province have been so affected by almost three centuries of continuous destruction and exploitation that no examples of untouched virgin forest remain, and very few of only slightly altered forest. This may mean that we can never attain a picture – and especially a comprehensive one – of the Island's pre-settlement forest. It is likely that in those forested areas that have been less heavily disturbed, the ground flora component has been less affected by human activity than the trees – the Inventory could contain valuable information in this respect, but in order to determine whether this is so, further comparative field work on some of the sites considered to have been less-disturbed (e.g. the Townshend Woodlot and equivalent sites – see Sobey 1993) is required before we can evaluate the extent to which the ground flora of Island forests in general has been affected by human intervention.

Another source of historical information are written records : there are some useful early accounts (especially valuable are Stewart (1806) and Johnstone (1822)) – though all are descriptive, contain no quantitative information on plant species, and very little that can be geographically pin-pointed. There is clearly further work to be done in synthesizing the information contained in the various early accounts -- plus the extracting of whatever information on tree species distribution exists in the as yet unstudied early land surveys and maps housed in the Provincial Archives.

Until either of the above lines of research are pursued further, our recourse must be to make full use of the historical speculations that do exist – the only useful one is that presented by Erskine (1960) : based on some of the early published accounts, and from his observations of the Island's forests in the 1950's, he cogently speculated about the make-up of the pre-settlement forest – I present a summary of his findings in Table 8. Where possible I have attempted to equate the TWINSPAN groups of the Inventory with Erskine's forest-types – see the General Description for each group in Appendix 1, and the discussions in Appendix 2. I have also in Appendix 2 considered in a tentative way how we might attempt to map these pre-settlement forest-types using data that is currently available, especially from aerial photography. Here in this main text, I will only note that some of the TWINSPAN groups (e.g. Groups 3, 5+6+7, and 13+14) appear to correspond to some of Erskine's climax forest-types – those that do not (Groups 8, 9, and 10), appear to be successional types resulting from human intervention.

THE TWINSPAN GROUPS AND WOODLAND CONSERVATION

The analysis of the Inventory data has indicated the principal forest-types of Prince Edward Island – although as noted above, it is possible that some rarer forest-types have either not turned up at the 240 sample sites or have not been recognized by the analysis. Of the various forest-types that have been recognized, we might ask whether there are suitable examples protected within the province's Natural Areas system ? There are at present twelve woodland Natural Areas having some form of protection (Sobey 1993); in addition three other candidate sites were examined by the Island Nature Trust in the 1980's but have not yet received designation as Natural Areas. About nine of these fifteen sites are of the climax hardwood type (some of these were designated because they contain rare tree species such as red oak (*Quercus rubra*) or ironwood (*Ostrya virginiana*); the remainder are relatively small areas comprising stands of the rarer conifers of the Island (i.e. hemlock, cedar, and red, white and jack pine).

There is thus an under-representation of wet deciduous woodland – of the present sites only one (St. Chrysostome Cedars) falls within this category; also missing are the black spruce - dominated forests – both the wet and dry variants. It may be that both of these forest-types are sufficiently common, and at the same time subjected to such low levels of pressure, that special protective measures are not required for them, but this needs examination. The

TABLE 8. A speculative reconstruction by Erskine (1960) of the forests of Prince Edward Island before the period of European settlement – the following table is my interpretation of Erskine's descriptive text (pp.17-18).

'UPLAND' AREAS : Tolerant Hardwood Forest

A mixed forest of sugar maple, beech, yellow birch (+ red maple) and their coniferous associates (white pine, hemlock, red spruce), with possible subdivisions as follows :

The dry hilltops of the central and south-east uplands	–	pure stands of beech
The more gradual slopes of the central uplands; the north-east peninsula and the upland areas of west Prince.	–	sugar maple + some yellow birch
North-facing slopes/shady ravines (especially in the central and south-eastern uplands)	–	red maple and hemlock
Clay slopes on the O'Leary soils series in west Prince	–	red maple, or red maple with yellow birch

'LOWLAND' AREAS :

Wetter soils	–	**Red Maple Forest :** red maple (plus in places : cedar, black ash, white ash, elm) **Cedar Woods** (on sandy soils with a high water table)
Sandy soils	–	**Pine Forest :** white pine, or white pine with red oak (plus in places red pine, grey birch, occasional black spruce)
Swamps/Bogs	–	**Black Spruce Forest :** black spruce, larch
Exposed Coastal Areas	–	**White Spruce Forest :** white spruce

other vegetation-types recognized by the Inventory analysis (i.e. the conifer-dominated successional and disturbed forests – Groups 8, 9 and 10) are so common as not to require protection, and being successional communities are likely anyway to be transitory on any site.

Another aspect of rarity concerns individual plant species, especially the ground flora species : the first Inventory report (Sobey 1993) listed those woodland plant species which (from their absence or low occurrence in the Inventory) appeared to be either uncommon or rare. In any future assessment of the abundance and distribution of such species, the results of the plant community analysis should prove useful : for example, with the aid of Erskine (1960) and other floras, the Inventory ground flora groups in which such species are likely to occur could be identified, and then using the Inventory datafiles, particular sites containing these woodland-types could be pin-pointed exactly for the purpose of visiting.

It is appropriate here to comment on a point raised in my first report (Sobey 1993) – i.e. on the factors responsible for the geographical distributions of the ground flora species across the Island (as shown by the species maps in that report). I speculated that an important factor determining these distributions was likely to be the presence of appropriate habitat. The plant-community analysis indicates that this is indeed so : without labouring the point, the maps of the ground flora groups in Appendix 1 of this report indicate that they have distinctive geographical distributions on the Island. These distributions in turn will be a major factor affecting the geographical distributions of their component species shown in the maps of the first report. However, that the availability of suitable habitat does not account entirely for the distributions is evident from the fact that quite a number of species were recorded more prominently in either the western or the eastern regions of the Island even though the community-types in which they occur are common in both parts (i.e. most of the species in geographical Group D of the first report, e.g. *Galium palustre*, *Equisetum arvense*, *Ilex verticillata*, and *Lycopus uniflorus* were rarely recorded in the eastern region, although Ground Flora Group 3 (for which they are 'selective' species) commonly occurs there, while *Ptilidium pulcherrimum*, and *Dryopteris cristata* were rarely recorded in the western region.

THE TWINSPAN GROUPS AS INDICATORS OF TREE PRODUCTION

As noted in the Introduction, elsewhere in Canada, the ground flora is being used as an indicator of the potential tree productivity of forest sites. Although the inclusion of the ground flora in the 1991 Inventory was not specifically designed for this purpose, some preliminary calculations (though without any statistical analysis) were carried out using the data from the variable-radius plots and for the two measured trees at each sampling point (Table 9). It is evident that there are notable differences between the TWINSPAN groups in some of the tree productivity parameters used in the Inventory : in terms of both the timber biomass per hectare and in their growth indices, the hardwood groups (5, 6, 7) and white spruce woods (Group 10) have higher values than the wet deciduous wood (Group 3) and most of the conifer groups (9, 13, 14). It is thus very likely that, as elsewhere, the ground flora in Prince Edward Island forests could be used as an indicator of the potential tree production at a site. However, if such a system were to be developed in future, it would be better to use ground flora plots larger than 4 m^2 in order to reduce the risks of the misclassification of sites due to the chance absence of species.

TABLE 9. Standard tree performance parameters calculated for the eleven TWINSPAN groups – the values are the means for each group.[1]

TWINSPAN Group (no. of plots)	Basal Area[2] (m^2 /ha)	Standard Index 1[3] (m)	Standard Index 2[3] (m)	Conifer Index[4] (m)
3 (156)	26.3	13.7	13.1	13.0
5 (77)	31.7	15.2	14.9	14.8
6 (196)	31.0	15.1	14.8	14.9
7 (155)	29.4	14.6	15.0	14.5
8 (165)	31.3	14.2	14.1	14.3
9 (118)	26.4	14.0	13.5	14.0
10 (135)	34.0	16.0	15.5	16.2
11 (21)	32.9	14.9	15.1	15.4
12 (12)	23.5	12.0	11.9	11.2
13 (29)	23.1	11.8	10.9	11.8
14 (51)	18.8	11.8	13.3	12.0

1. Data provided by W. Glen of Prince Edward Island Forestry Branch.
2. Basal area – of tree stems (m^2 /ha) – determined from the tree sample in the variable radius plots.
3. Standard Indices 1 and 2 – the calculated mean height (m) of a theoretical white spruce tree of a breast height age of 50 years – derived from data for the first and second measured tree at each sampling point respectively.
4. Conifer Index – the same parameter as for the Standard Index (see 2 above), but based only on the conifer trees measured.

RECOMMENDATIONS

In a future forest inventory :

1. If the ground vegetation were to be assessed in a future forest inventory, in order to avoid the problem of the chance absence of species from small plots, the plot size should be increased from 4 m^2 to at least 100 m^2 (i.e. a circular plot of radius 5.65 m). Within this area all species should be listed and their percentage cover estimated to the nearest 10% – the coverage of litter/bare ground should also be estimated. The surrounding area (up to 1000 m^2 – i.e. radius 17.8 m) should then be searched and additional species listed.

2. If resources were not sufficient to carry out the above assessment at all five plots at a site, then it might be done at one of the five plots, preferably chosen randomly, with the option of moving to another plot should the first be unsuitable because of a high level of apparent heterogeneity in the ground vegetation, or for some other reason.

Work relevant to woodland conservation :

3. Those rarer woodland plant community-types which, either from historical or current records, appear to occur on the Island, but which were not identified in the multivariate analysis (e.g. pine woods, cedar swamps and nutrient-rich fern-herb forest) should be assessed in a separate survey to determine their geographical distribution and abundance, as well as their species composition and environmental properties.

Future work on forest history :

4. All of the existing written evidence on the history of the forests of Prince Edward Island – in particular, on the forest composition at the start of pre-European settlement, should be examined to give a synthesized picture. In particular whatever information on tree species distribution exists in the as yet unstudied early land surveys and maps housed in the Provincial Archives should be examined.

5. The earliest aerial photographic survey of the Island (1935) contains a wealth of historical information – not only on the state of the forests at that time, but also on forest changes of the previous fifty years or so – especially on the successional forest. The tree species composition of the forest canopy dominants for each stand is being 'photo-interpreted' by the provincial Forestry Branch. The computerized database resulting should be analysed to determine the spatial and temporal pattern of forest succession on abandoned farmland since the early years of this century.

6. The species composition and other properties of those present-day forest sites which have been less-disturbed and which as a result may approximate more closely to the pre-settlement forest (e.g. sites such as the Townshend Woodlot Natural Area) should be recorded in detail in order to enable comparison with the plant-community types identified by the multivariate analysis.

7. The data contained in the 1990 false-colour infra-red aerial photographic survey of the Island (stored on computer data-base and linked to the Geographic Information System (G.I.S.) for the province) should be manipulated as discussed in this report, to add information on the present distribution of the plant community-types identified by the multivariate analysis.

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APPENDIX 1

THE FOREST VEGETATION-TYPES OF PRINCE EDWARD ISLAND : SUMMARY DESCRIPTIONS FOR EACH OF THE ELEVEN PRINCIPAL GROUND FLORA PLOT GROUPS GENERATED BY THE TWINSPAN ANALYSIS

For each TWINSPAN group its ground flora species composition, its tree and shrub components, its forest-stand properties, and the environmental factors operating at the sites at which it occurred are summarized. Also presented is a map showing the geographical distribution on the island of the plots of the group. The detailed data from which these summaries are derived are contained in the tables of Appendix 3, and each of the groups is discussed extensively in Appendix 2.

In the TWINSPAN analysis the 1127 4 m^2 ground flora plots analysed were divided at the fourth division level (Figure 2) into 15 groups ranging in size from one plot to 196 plots – only the eleven groups with more than 10 plots are described here, plus the two sub-groups at the fifth division level (see Appendix 5: Figure 5-1) of the more heterogeneous Group 3 (detailed data tables comparing these two sub-groups are contained in Appendix 5).

Because of the nature of TWINSPAN, the plots falling in any group are likely to be similar in their overall ground flora species composition – collectively, the plots of a group can thus be considered to represent a recognizable ground flora community-type. And because the plant community of the forest floor shows important inter-relationships and dependencies with the tree canopy, the TWINSPAN groups are also indicative of the total plant community or vegetation type.

The degree to which these groups constitute distinctive and real community types can however only be interpreted in terms of their reality on the ground. Because TWINSPAN will continue to sub-divide groups of any size above a minimum set by the program, divisions at lower levels are more likely to represent chance differences in the species occurring in the 4 m^2 plots – in fact the 15 groups at the fourth division level shown in Figure 2 were further subdivided by the TWINSPAN analysis into *66 groups* at the seventh division level. It is quite unlikely that there are 66 different plant community types in the forests of PEI – but are there likely to be even eleven ? In fact, when the eleven groups are examined in terms of their species composition and environmental factors, it is evident that though each appears to have a certain ecological validity, some of them are variants of more general community-types. When these variants are combined, the eleven groups can be reduced to five main types of plant community – these are : wet rich deciduous woodland (Group 3); dry hardwood forest (Groups 5, 6 and 7); disturbed conifer-dominated forest (Groups 8 and 9); old field white spruce woods (Group 10); and black spruce - dominated forest (Groups 13 and 14). (Of the two small remaining groups : Group 11 seems to represent a very localized ground flora type determined by the canopy in the immediate area of the plots, while Group 12 appear to be a transition vegetation-type between Groups 3 and 13.)

Thus, bearing in mind the above points, as well as the qualifications contained in the 'General Descriptions' at the start of each group, the following TWINSPAN plot groups can be considered to constitute recognizable vegetation types for the forests of Prince Edward Island.

TWINSPAN GROUP DESCRIPTIONS :

DEFINITON OF TERMINOLOGY

VEGETATION

The species of ground flora, trees, shrubs and regeneration trees are listed for each of the eleven TWINSPAN groups in the following categories:

GROUND FLORA

MEAN TAXA PER PLOT – The mean number of ground flora species per 4 m^2 plot (±S.E.). Each value is assigned a comparative grading of 'low','medium' or 'high' – obtained by dividing the range for the values into three equal parts : low - < 7.3 species /plot, medium - ≥ 7.3 to < 10.5, high - ≥ 10.5 .

FREQUENT SPECIES – Species occurring in ≥ 25% of the 4 m^2 plots in a TWINSPAN group – listed in order of descending frequency. Since a 4 m^2 ground flora plot contained on average only 35% of the ground flora species at a site (Sobey 1993), the species listed would have achieved much higher frequency levels if larger plots had been used, and thus they can be considered equivalent to the 'constant species' of the group as defined by Bunce (1982).

SELECTIVE SPECIES – Species whose frequency in the TWINSPAN group was significantly higher (χ^2 goodness of fit, $p < 0.001$) than in all of the 1200 Inventory plots taken together – listed in order of descending χ^2 value.

TREES – (i.e. woody species ≥ 9 cm dbh) :

MEAN TAXA PER PLOT – The mean number of tree species per variable radius plot (± S.E.). Each value is assigned a comparative grading of 'low', 'medium' or 'high' – obtained by dividing the range of the values into three equal parts : low - < 2.5 species/plot, medium - ≥ 2.5 to < 3.0, high - ≥ 3.0 .

FREQUENT SPECIES – Tree species recorded in ≥ 25% of the variable radius plots associated with the ground flora group, listed in order of descending frequency. Species not in brackets were recorded at ≥ 50% of the plots, while species in brackets were recorded at ≥ 25% but < 50%.

DOMINANT SPECIES – Those tree species associated with the ground flora group whose mean percentage contribution to the total tree biomass in the variable radius plots was ≥ 10%. All species are listed in order of descending biomass contribution, with the species not in brackets contributing ≥ 20%, while those in brackets contributed ≥ 10% but < 20%.

SELECTIVE SPECIES – Those tree species whose frequency in the ground flora TWINSPAN group was significantly greater (χ^2 goodness of fit, $p < 0.01$) than in all of the 1200 Inventory plots taken together – listed in order of descending χ^2 value. Species not in brackets were significant at a probability level of < 0.001, while those in brackets were so at a level of < 0.01.

SHRUBS / SMALL TREES – (i.e. woody plants of height ≥ 1.3 m but of dbh < 9cm) :

MEAN TAXA PER PLOT – The mean number of shrub/small tree species per 16 m^2 plot (± S.E.). Each value is assigned a comparative grading of 'low','medium' or 'high' – obtained by dividing the range for the values into three equal parts : low - < 1.7 species /plot, medium - ≥ 1.7 to < 2.0, high - ≥ 2.0 .

MEAN OF TOTAL SHRUBS/ SMALL TREES PER PLOT – The mean of the total number of shrubs or small trees (summed for all species) per 16 m^2 plot (± S.E.). Each value is assigned a comparative grading of 'low', 'medium' or 'high' – obtained by dividing the range of values into three equal parts : low - < 7.3 plants /plot, medium - ≥ 7.3 to < 8.9, high - ≥ 8.9.

FREQUENT SPECIES – Shrub/small tree species occurring in ≥ 10% of the 16 m^2 plots associated with each ground flora group – listed in order of descending frequency. Species not in brackets occurred in ≥ 20% of the plots, while species in brackets occurred in ≥ 10% but < 20%.

SELECTIVE SPECIES – defined exactly as for trees.

REGENERATION TREES – (i.e. of height ≥ 15 cm but < 1.3 m) :

MEAN TAXA PER PLOT – The mean number of regeneration trees per 4 m^2 plot (± S.E.). Each value is assigned a comparative grading of 'low', 'medium' or 'high' – obtained by dividing the range for the mean species per plot into three equal parts : low - < 0.96 species /plot, medium - ≥ 0.96 to < 1.2, high - ≥ 1.2 .

MEAN OF TOTAL PLANTS PER PLOT – The mean of the total number of regeneration trees (summed for all species) per 4 m^2 plot (± S.E.). Each value is assigned a comparative grading of 'low','medium' or 'high' – obtained by dividing the range of values into three equal parts : low - < 3.6 regeneration trees /plot, medium - ≥ 3.6 to < 4.7, high - ≥ 4.7.

FREQUENT SPECIES – Regeneration trees occurring in ≥ 10% of the 4 m^2 plots in a ground flora group – listed in order of descending frequency. Species not in brackets occurred in ≥ 20% of the plots, while species in brackets occurred in ≥ 10% but < 20%.

SELECTIVE SPECIES – defined exactly as for trees.

STAND AND TREE PROPERTIES

FOREST TYPE – The three most frequent forest type classes recorded at the sites where the ground flora group occurred are listed in descending order, with the proportion of plots in each class (to the nearest 10%) written in superscript. (HH : > 75% hardwood; HS : 51 - 75% hardwood; SH : 51 - 75% softwood; SS : > 75% softwood.)

WOODLAND SIZE – The most frequent of the three woodland size classes for the ground flora group (as determined from 1 : 50,000 maps) is listed: (i.e. ≤5 km^2; >5 - 10 km^2; >10 km^2). An asterisque indicates a significant positive association (χ^2 test, $p < 0.05$) with the size class. Where two size classes were close in value they are both listed in descending order.

STAND AGE – The three most frequent stand age classes recorded at the sites of the ground flora group are listed in descending order, with the proportion of plots in each class (to the nearest 10%) written in superscript. (I - immature; M - mature; O - over-mature; U - uneven-aged.)

STOCKING CLASS – The three most frequent tree stocking classes recorded at the sites of the ground flora group are listed in descending order, with the proportion of plots in each class (to the nearest 10%) written in superscript. (1: 0 - 25%; 2 : 26 - 50%; 3 : 51 - 75%; 4 : 76 - 100%.)

% BIOMASS – The sum (to the nearest 10%) of the mean percentage contributions of hardwood trees (H) (i.e. broad-leaves) and softwood trees (S) (i.e. conifers) to the total tree biomass in the variable radius plots associated with the ground flora group is written in superscript.

TREE HEIGHT – The mean height (m) of the measured trees for the plots in the ground flora group. Each mean height is assigned a comparative grading of 'low','medium' or 'high' – obtained by dividing the range of the mean heights into three equal parts : low - < 13 m; medium - ≥ 13 m to < 15 m; high - ≥ 15 m.

TREE AGE – The mean age (years) of the measured trees for the plots in the ground flora group. Each mean age is assigned a comparative grading of 'low','medium' or 'high' – obtained by dividing the range of the mean ages into three equal parts : low - < 52 y; medium - ≥ 52 y to < 60 y; high - ≥ 60 y.

ACTUAL DENSITY – The mean of the percentage 'actual tree crown density' of the trees in the variable radius plots of the ground flora group. Each mean is assigned a comparative grading of 'low','medium' or 'high' – obtained by dividing the range of the mean values into three equal parts : low - < 62%; medium - ≥ 62% to < 76%; high - ≥ 76%.

STAND ORIGIN / HISTORY – The three most frequent stand origin classes recorded at the sites of the ground flora group are written in descending order – with the proportion of plots in each class (to the nearest 10%) written in superscript. (For some groups a fourth class is listed in brackets – if considered ecologically significant.) (OF - old field; PC - partial cut or thinning; Bu - burn; SW - swampy; BOG - bog; N - nothing evident.)

STATUS IN 1935 – The proportion of sites in the ground flora group classified as forest-covered (FC) or cleared land (CL) in 1935 (as determined from aerial photographs) is written in superscript to the nearest 10%.

ENVIRONMENT

GEOGRAPHICAL DISTRIBUTION – The proportion of plots in the ground flora group located in each of the three geographical regions of the province (Figure 1) is written in superscript to the nearest 10% – in order of descending value. (W - west : ie. west of the Bedeque-Malpeque isthmus; C - central : between the Bedeque-Malpeque isthmus and the Hillsborough River; E - east : east of the Hillsborough River and Tracadie Bay.)

DISTANCE FROM THE COAST – The mean straight-line distance (km) of the plots in the ground flora group from the sea coast, including larger bays but excluding tidal rivers and estuaries (as determined from 1 : 50,000 maps). Each distance is assigned a comparative grading of 'low', 'medium' or 'high' – obtained by dividing the range of the mean distances into three equal parts : low - < 5.0 km; medium - ≥ 5.0 but < 6.4; high - ≥ 6.4 .

DISTANCE FROM THE NEAREST ROAD OR BUILDING – The mean straight-line distance (m) of the plots in the ground flora group from the nearest road or building (as determined from 1 : 50,000 maps). Each distance is assigned a comparative grading of 'low', 'medium' or 'high' – obtained by dividing the range of the mean distances into three equal parts : low - < 420 m; medium - ≥ 420 but < 509; high - ≥ 509 .

ELEVATION – The mean elevation above sea-level (m) of the plots in the ground flora group (as determined from 1 : 50,000 maps). Each elevation is assigned a comparative grading of 'low', 'medium' or 'high' – obtained by dividing the range of the mean elevations into three equal parts : low - < 29.5 m; medium - ≥ 29.5 but < 40; high - ≥ 40.

SLOPE – The proportion (to the nearest 10%) of sloping (S) or level (L) plots in each ground flora group is recorded as a superscript, along with the mean slope (degrees) in all plots (including level plots), plus a comparative grading of the slopes as 'low', 'medium' or 'high' – obtained by dividing the range of the mean slopes (ignoring the small Group 12 – which had the lowest slope) into three equal parts: low - < 1.8°; medium - ≥ 1.8° to < 2.2°; high - ≥ 2.2° .

CORN HEAT UNITS – The mean of the corn heat unit values for the plots in the ground flora group (as determined from map values). Each corn heat unit is assigned a comparative grading of 'low', 'medium' or 'high' – obtained by dividing the range of the mean units into three equal parts : low - < 2298 ; medium - ≥ 2298 but < 2311; high - ≥ 2311 .

SOIL SERIES – The three or four most frequent soil series types at the sites of the ground flora group (as determined from 1 : 10,000 soil survey maps of the province) are listed in descending order with the proportion of plots of each type (to the nearest 10%) written in superscript. (Al - Alberry; Bp - Baptist Point; Ch - Charlottetown; Cu - Culloden; Ma - Malpeque; Mg - Margate; Mp - Mossy Point; Or - Orwell; Rp - Rocky Point; Wn - Winsloe.)

SOIL TEXTURE – The three or four most frequent soil textural classes recorded at the sites of the ground flora group are listed in descending order, with the proportion of plots in each class (to the nearest 10%) written in superscript. (CL - clay loam; SCL - sandy clay loam; SIC - silty clay; L - loam; SL - sandy loam; LS - loamy sand; O - organic.)

SOIL DRAINAGE – The more frequent soil drainage classes recorded at the sites of the ground flora group are listed in descending order with the proportion of plots in each class (to the nearest 10%) written in superscript. (W - well-drained; M - moderately well-drained; I - imperfectly drained; P - poorly drained.)

pH – The mean pH of the humus (H) horizon for the plots in the ground flora group. Each pH value is assigned a comparative grading of 'low','medium' or 'high' – obtained by dividing the range of the mean pH's into three equal parts : low - pH < 4.4; medium - pH ≥ 4.4 but < 4.9; high - pH ≥ 4.9 .

ORGANIC MATTER (%) – The mean % organic matter for the H horizon of the plots in the ground flora group – calculated by mutiplying the % carbon value by a factor of 1.724. Each value is assigned a comparative grading of 'low','medium' or 'high' – obtained by dividing the range of the mean values into three equal parts : low - < 35%; medium - ≥ 35% but < 50%; high - ≥ 50%.

N : C RATIO (%) – The N : C ratio for the H horizon of the ground flora group – obtained by dividing the mean total nitrogen value for the plots in the group by the mean total carbon value, and expressing it as a percentage. Each value is assigned a comparative grading of 'low', 'medium' or 'high' – obtained by dividing the range of the N : C values into three equal parts : low - < 4.1; medium - ≥ 4.1 but < 5.0; high - ≥ 5.0 .

AVAILABLE PHOSPHORUS (ppm) – The mean of the available phosphorus for the H horizon of the plots in the ground flora group. Each value is assigned a comparative grading of 'low', 'medium' or 'high' – obtained by dividing the range of the mean values into three equal parts : low - < 160 ppm; medium - ≥ 160 ppm but < 220 ppm; high - ≥ 220 ppm.

AVAILABLE CALCIUM (ppm) – The mean of the available calcium in the H horizon of the plots in the ground flora group. Each value is assigned a comparative grading of 'low', 'medium' or 'high' – obtained by dividing the range of the mean values into three equal parts : low - < 2000 ppm; medium - ≥ 2000 ppm but < 3600 ppm; high - ≥ 3600 ppm.

DISTRIBUTION MAP

The map shows the sampling sites (out of 240) at which a particular ground flora group occurred. A dot at a site indicates that at least one of the five 4 m^2 ground flora sampling plots at that site was classified in that group. The sample sites where the group was not present are visible as small points (see Figure 1 for a more clear indication of the location of all of the sample sites).

GROUP 3

156 plots (13.8%)

GENERAL DESCRIPTION

A ground flora community-type of frequent occurrence, especially at low elevation sites in woodland of varying sizes in the western region, as well as parts of the eastern region of the island; it is associated with comparatively base-rich but poorly-drained soils. The tree canopy contains a mixture of broad-leaves and conifers, with red maple predominating. It is a species-rich community-type at all levels – in trees, shrubs and ground flora, characterised by an exceptionally large number of selective species. Key site factors associated with the group : low elevation, level land, poor soil drainage, Rocky Point, Winsloe, Mossy Point soil series, high base content, high nitrogen content. Key stand factors : mixed red maple-dominated forest, older trees, medium stocking rate.

This group overlaps somewhat in species composition with Group 5, and substantially with the small Group 12. It sub-divides into a dryer and wetter variant (see Groups 3A and 3B). It does not show any significant spatial association with any other TWINSPAN group. It appears to be a derivative of Erskine's lowland red maple forest – though with considerable effects due to cutting and other disturbances.

GROUND FLORA :

Mean taxa/plot = 13.7 ± 0.44 (S.E.) (*high*)

Total taxa recorded = 161

Taxa with frequency > 5% = 69

FREQUENT SPECIES (21 species) :

Rubus pubescens, Impatiens capensis, Carex spp., Dryopteris spinulosa, Onoclea sensibilis, Osmunda cinnamomea, Fragaria virginiana, Viola pallens, Galium triflorum, Maianthemum canadense, Mitella nuda, Mnium spp., Trientalis borealis, Cornus stolonifera, Aralia nudicaulis, Sphagnum spp., Athyrium filix-femina, Cornus canadensis, Rhytidiadelphus triquetrus, Pleurozium schreberi, Taxus canadensis.

SELECTIVE SPECIES (44 species) :

Rubus pubescens, Impatiens capensis, Mnium spp., Mitella nuda, Cornus stolonifera, Onoclea sensibilis, Athyrium filix-femina, Osmunda cinnamomea, Galium triflorum, Fragaria virginiana, Rhytidiadelphus triquetrus, Ranunculus repens, Galium palustre, Ribes lacustre, Gymnocarpium dryopteris, Equisetum sylvaticum, Thalictrum polygamum, Ribes hirtellum, Caltha palustris, Eupatorium maculatum, Lycopus uniflorus, Thelypteris phegopteris, Equisetum spp., Prunus virginiana, Equisetum arvense, Aster puniceus, Circaea alpina, Alnus rugosa, Sphagnum spp., Carex spp., Aster umbellatus, Epilobium angustifolium, Typha latifolia, Viola pallens, Taxus canadensis, Dryopteris cristata, Ribes glandulosum, Ptilidium pulcherrimum, Grass spp., Lonicera canadensis, Corylus cornuta, Dryopteris spinulosa, Rosa virginiana, Ilex verticillata.

TREES :

Mean taxa/plot = 3.4 ± 0.12 (S.E.) (*high*)

FREQUENT SPECIES : balsam fir, red maple, white spruce, (white birch)

DOMINANT SPECIES : red maple, (white spruce, balsam fir)

SELECTIVE SPECIES : cedar, elm, larch

SHRUBS / SMALL TREES :

Mean taxa/plot = 2.3 ± 0.11 (S.E.) (*high*)

Mean total shrubs/plot = 10.4 ± 0.79 (S.E.) (*high*)

FREQUENT SPECIES : balsam fir, red maple, speckled alder, (mountain maple, trembling aspen, white spruce, white birch, cedar, willow species)

SELECTIVE SPECIES : speckled alder, cedar, mountain maple, willow species, *Corylus cornuta*, trembling aspen, *Ilex verticillata*, (black ash, *Taxus canadenis*)

REGENERATION TREES :

Mean taxa/plot = 0.69 ± 0.075 (S.E.) (*low*) **Mean total plants/plot = 2.6 ± 0.58 (S.E.) (*low*)**

FREQUENT SPECIES : **(red maple, balsam fir)**

SELECTIVE SPECIES : **(white ash)**

STAND & TREE PROPERTIES

Forest Type	*Woodland Size (km^2)*	*Stand Age*	*Stocking Class*
HS^3 HH^3 SH^3	≤5 km^2	U^4 M^3 I^2	3^4 4^3 2^2

% Biomass	*Tree Height (m)*	*Tree Age (yr)*	*Actual Density (%)*
H^5 S^5	14.5 *(med)*	60 *(high)*	69 *(med)*

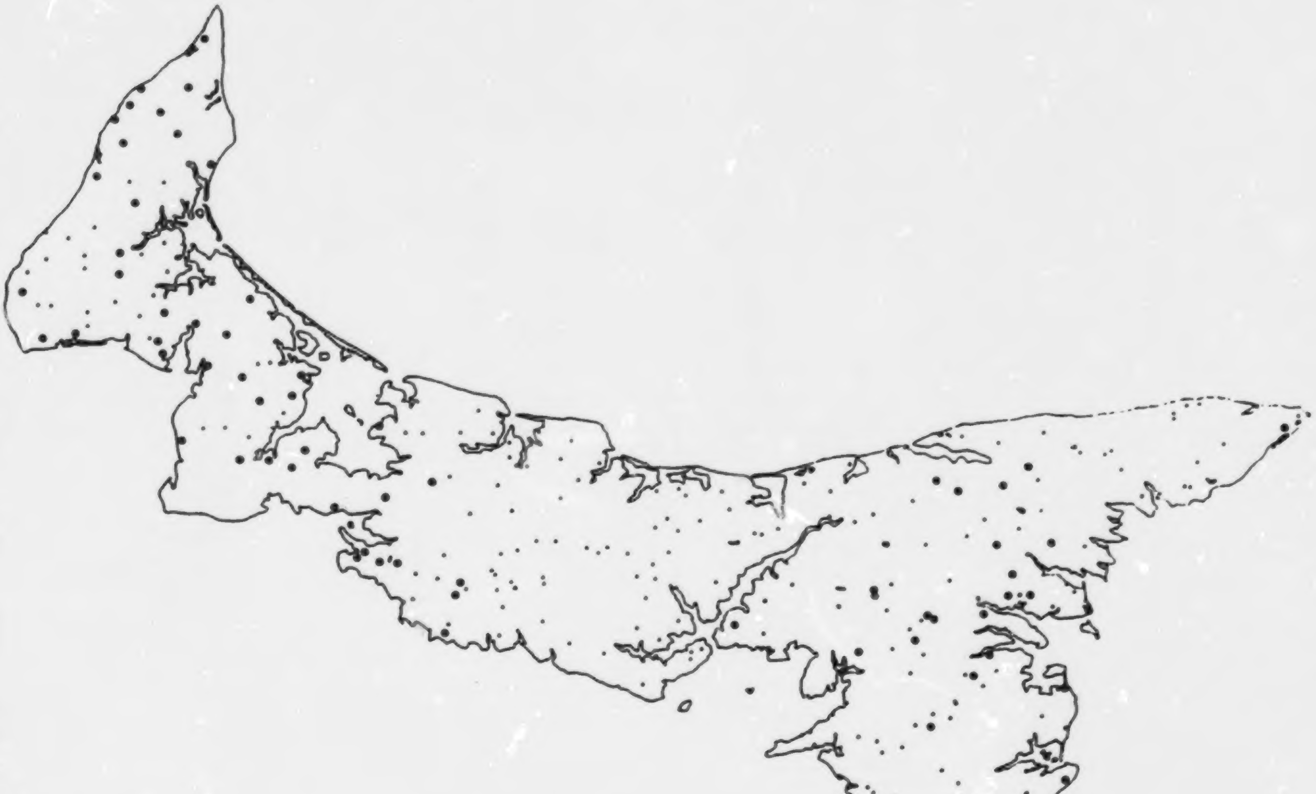
Stand Origin/History	*Status 1935*
PC^3 N^3 OF^2 (SW^2)	FC^9 CL^1

ENVIRONMENT

Geographical Distribution	*Distance to Coast (km)*	*Distance to Road (m)*	*Elevation (m)*	*Slope*
W^5 E^3 C^2	4.7 (*low*)	454 (*med*)	19.5 (*low*)	L^7 S^3(1.7°)(*low*)

Corn Heat Units	*Soil Series*	*Soil Texture*	*Soil Drainage*
2304 *(med)*	Rp^2 Wn^1 Mp^1 Bp^1	SCL^2 LS^2 SL^1 (O^1)	P^4 M^2 W^2

pH	*% O M*	*N : C (%)*	*P (ppm)*	*Ca (ppm)*
5.4 *(high)*	38 *(med)*	5.9 *(high)*	110 *(low)*	5100 *(high)*



GROUP 3A

71 plots (5.9%)

GENERAL DESCRIPTION

One of the two ground flora community sub-types occurring in wet deciduous woodland (see the General Description for Group 3) – distinguished from the other sub-type in such woodlands (Group 3B) by the higher frequency of particular ground flora species, some of which have a more ubiquitous distribution in other plot-types. The tree canopy is very similar to that of 3B except for : a higher level of white spruce and less of red maple; a lower frequency of overmature stands; and taller trees. Key factors distinquishing this sub-group from 3B : a lower frequency of poorly drained soils, and lower levels of soil organic matter, nitrogen, and base content (calcium and magnesium). Key stand factors : less red maple, greater past clearance than Group 3B.

This group overlaps substantially in species composition with Group 3B, with which it shows a high level of spatial association. It appears to represent the dryer end in the range of Erskine's lowland red maple forest – a further factor contributing to its differentiation from Group 3B may be its higher level of past clearance.

GROUND FLORA :

Mean taxa/plot = 14.2 ± 0.70 (S.E.) (*high*)

Total taxa recorded = 125 Taxa with frequency > 5% = 68

FREQUENT SPECIES (18 species) :

Rubus pubescens, Trientalis borealis, Dryopteris spinulosa, Athyrium filix-femina, Fragaria virginiana, Galium triflorum, Maianthemum canadense, Aralia nudicaulis, Carex spp., Cornus canadensis, Cornus stolonifera, Pleurozium schreberi, Viola pallens, Clintonia borealis, Viburnum cassinoides, Impatiens capensis, Mitella nuda, Aster puniceus.

SELECTIVE SPECIES (28 species) :

Athyrium filix-femina, Rubus pubescens, Galium triflorum, Fragaria virginiana, Cornus stolonifera, Prunus virginiana, Mitella nuda, Equisetum sylvaticum, Thelypteris phegopteris, Gymnocarpium dryopteris, Aster puniceus, Corylus cornuta, Epilobium angustifolium, Impatiens capensis, Rhytidiadelphus triquetrus, Ranunculus repens, Lonicera canadensis, Ribes glandulosum, Equisetum spp., Ribes lacustre, Dryopteris cristata, Circaea alpina, Alnus rugosa, Pyrola elliptica, Dryopteris spinulosa, Rubus canadensis, Thalictrum polygamum, Osmunda cinnamomea.

TREES :

Mean taxa/plot = 3.5 ± 0.18 (S.E.) (*high*)

FREQUENT SPECIES :	balsam fir, white spruce, red maple, (white birch, trembling aspen)
DOMINANT SPECIES :	white spruce, (red maple, balsam fir)
SELECTIVE SPECIES :	cedar, white ash, elm

SHRUBS / SMALL TREES :

Mean taxa/plot = 2.5 ± 0.17 (S.E.) (*high*) Mean total shrubs/plot = 9.6 ± 0.95 (S.E.) (*high*)

FREQUENT SPECIES :	balsam fir, red maple, (speckled alder, pin cherry, white spruce, trembling aspen, mountain maple, *Corylus cornuta*)
SELECTIVE SPECIES :	*Corylus cornuta*, white ash, choke cherry, cedar, speckled alder, mountain maple, trembling aspen, (*Cornus stolonifera*, pin cherry, willow spp.)

REGENERATION TREES :

Mean taxa/plot = 0.96 ± 0.13 (S.E.) (*med*) Mean total plants/plot = 3.2 ± 0.54 (S.E.) (*low*)

FREQUENT SPECIES : balsam fir, red maple, (white birch)

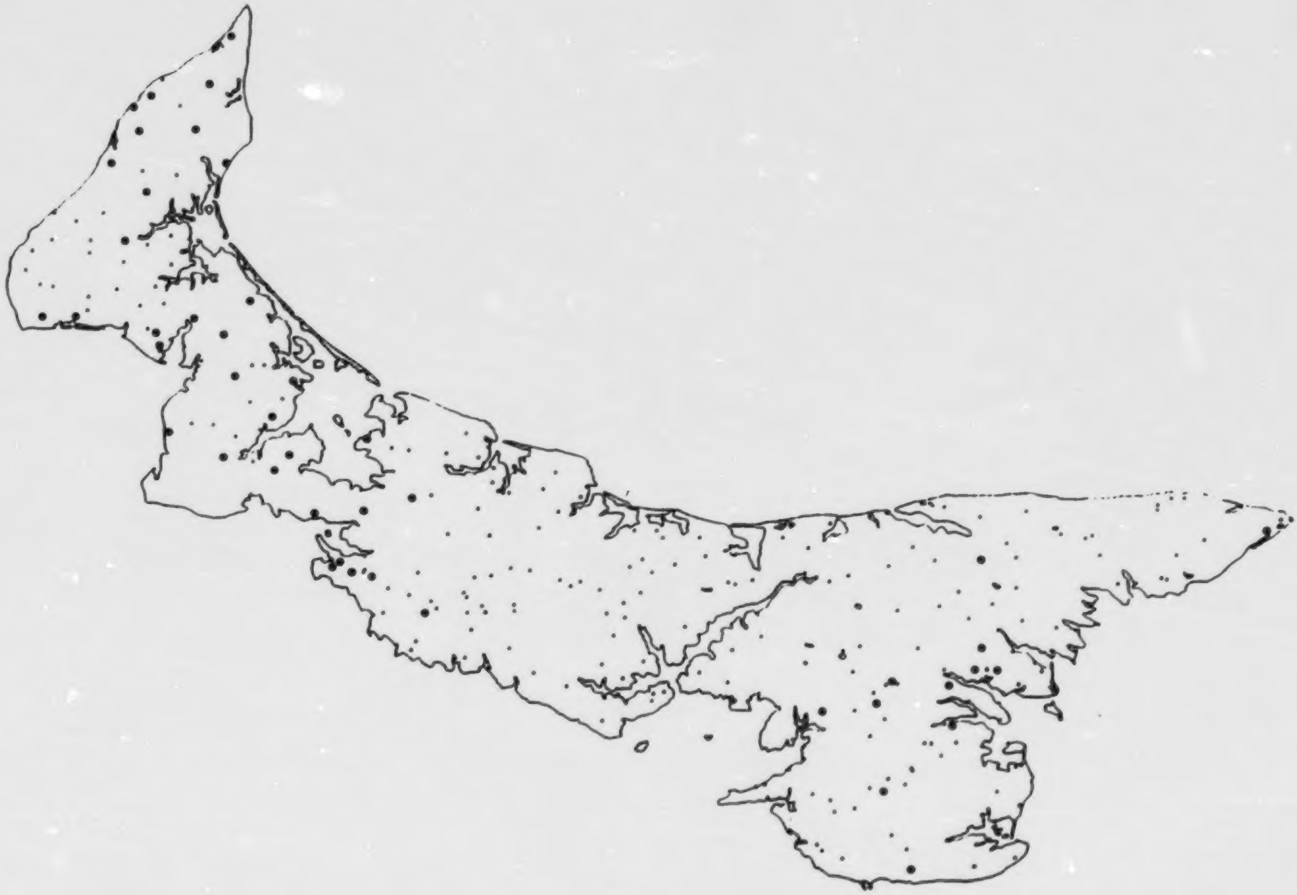
SELECTIVE SPECIES : (white ash)

STAND & TREE PROPERTIES

Forest Type	*Woodland Size (km^2)*	*Stand Age*	*Stocking Class*
HS^4 HH^3 SH^3	≤5 km^2	U^4 M^3 I^2	3^4 4^3 2^2
% Biomass	*Tree Height (m)*	*Tree Age (yr)*	*Actual Density (%)*
H^5 S^5	15.3 *(high)*	59 *(med)*	68 *(med)*
	Stand Origin/History	*Status 1935*	
	OF^3 PC^3 N^2	FC^8 CL^2	

ENVIRONMENT

Geographical Distribution	*Distance to Coast (km)*	*Distance to Road (m)*	*Elevation (m)*	*Slope*
W^6 E^2 C^2	4.3 *(low)*	400 *(low)*	19.3 *(low)*	L^5 S^5 (1.7°) *(low)*
Corn Heat Units	*Soil Series*	*Soil Texture*		*Soil Drainage*
2305 *(med)*	Rp^1 Bp^1 Mp^1	SCL^3 SL^2 LS^2		W^3 M^3 I^2
pH	*% O M*	*N : C (%)*	*P (ppm)*	*Ca (ppm)*
5.4 *(high)*	28 *(low)*	5.5 *(high)*	131 *(low)*	4030 *(high)*



GROUP 3B

85 plots (7.1%)

GENERAL DESCRIPTION

One of the two ground flora community sub-types occurring in wet deciduous woodland (see the General Description for Group 3) – distinguished from the other sub-type in such woodlands (Group 3A) by the higher frequency of particular ground flora species associated with richer and wetter soils. The tree canopy is very similar to that of 3A except for : a higher level of the dominant red maple, and less white spruce, a higher frequency of overmature stands, and shorter trees. Key factors distinquishing this sub-group from 3A : a higher frequency of poorly drained soils; higher levels of soil organic matter, nitrogen, and base content (calcium and magnesium). Key stand factors : more red maple, less past clearance.

This group overlaps substantially in species composition with Group 3A, with which it shows a high level of spatial association. It appears to represent the wetter end of the range of Erskine's lowland red maple forest – it also has a lower level of past clearance than 3A.

GROUND FLORA :

Mean taxa/plot = 13.3 ± 0.56 (S.E.) (*high*)

Total taxa recorded = 138 Taxa with frequency > 5% = 54

FREQUENT SPECIES (16 species) :

Rubus pubescens, Onoclea sensibilis, Impatiens capensis, Carex spp., Mnium spp., Osmunda cinnamomea, Sphagnum spp., Dryopteris spinulosa, Viola pallens, Mitella nuda, Cornus stolonifera, Rhytidiadelphus triquetrus, Taxus canadensis, Fragaria virginiana, Galium triflorum, Maianthemum canadense.

SELECTIVE SPECIES (33 species) :

Onoclea sensibilis, Impatiens capensis, Mnium spp., Rubus pubescens, Galium palustre, Osmunda cinnamomea, Mitella nuda, Eupatorium maculatum, Cornus stolonifera, Caltha palustris, Rhytidiadelphus triquetrus, Lycopus uniflora, Ribes lacustre, Thalictrum polygamum, Typha latifolia, Ranunculus repens, Ribes hirtellum, Equisetum arvense, Sphagnum spp., Fragaria virginiana, Galium triflorum, Carex spp., Gymnocarpium dryopteris, Ptilidium pulcherrimum, Equisetum spp., Aster umbellatus, Alnus rugosa, Equisetum sylvaticum, Circaea alpina, Taxus canadensis, Grass spp., Ilex verticillata, Smilacina trifolia.

TREES :

Mean taxa/plot = 3.5 ± 0.15 (S.E.) (*high*)

FREQUENT SPECIES :	balsam fir, red maple, (white spruce, white birch, larch)
DOMINANT SPECIES :	red maple, (balsam fir, white spruce)
SELECTIVE SPECIES :	elm, cedar, black ash, larch

SHRUBS / SMALL TREES :

Mean taxa/plot = 2.3 ± 0.12 (S.E.) (*high*) Mean total shrubs/plot = 11.0 ± 1.2 (S.E.) (*high*)

FREQUENT SPECIES :	balsam fir, speckled alder, red maple, (mountain maple, white birch, willow spp., cedar, trembling aspen)
SELECTIVE SPECIES :	speckled alder, cedar, mountain maple, *Ilex verticillata*, black ash, willow spp., larch

REGENERATION TREES :

Mean taxa/plot = 0.46 ± 0.081 (S.E.) (*low*) Mean total plants/plot = 2.1 ± 0.97 (S.E.) (*low*)

FREQUENT SPECIES :	(red maple)
SELECTIVE SPECIES :	none

STAND & TREE PROPERTIES

Forest Type	*Woodland Size (km²)*	*Stand Age*	*Stocking Class*
$HH^3\ HS^3\ SH^2$	≤5 km², > 10 km²	$U^3\ M^3\ O^2\ I^2$	$3^4\ 4^3\ 2^3$

% Biomass	*Tree Height (m)*	*Tree Age (yr)*	*Actual Density (%)*
$H^5\ S^5$	13.7 (*med*)	62 (*high*)	70 (*med*)

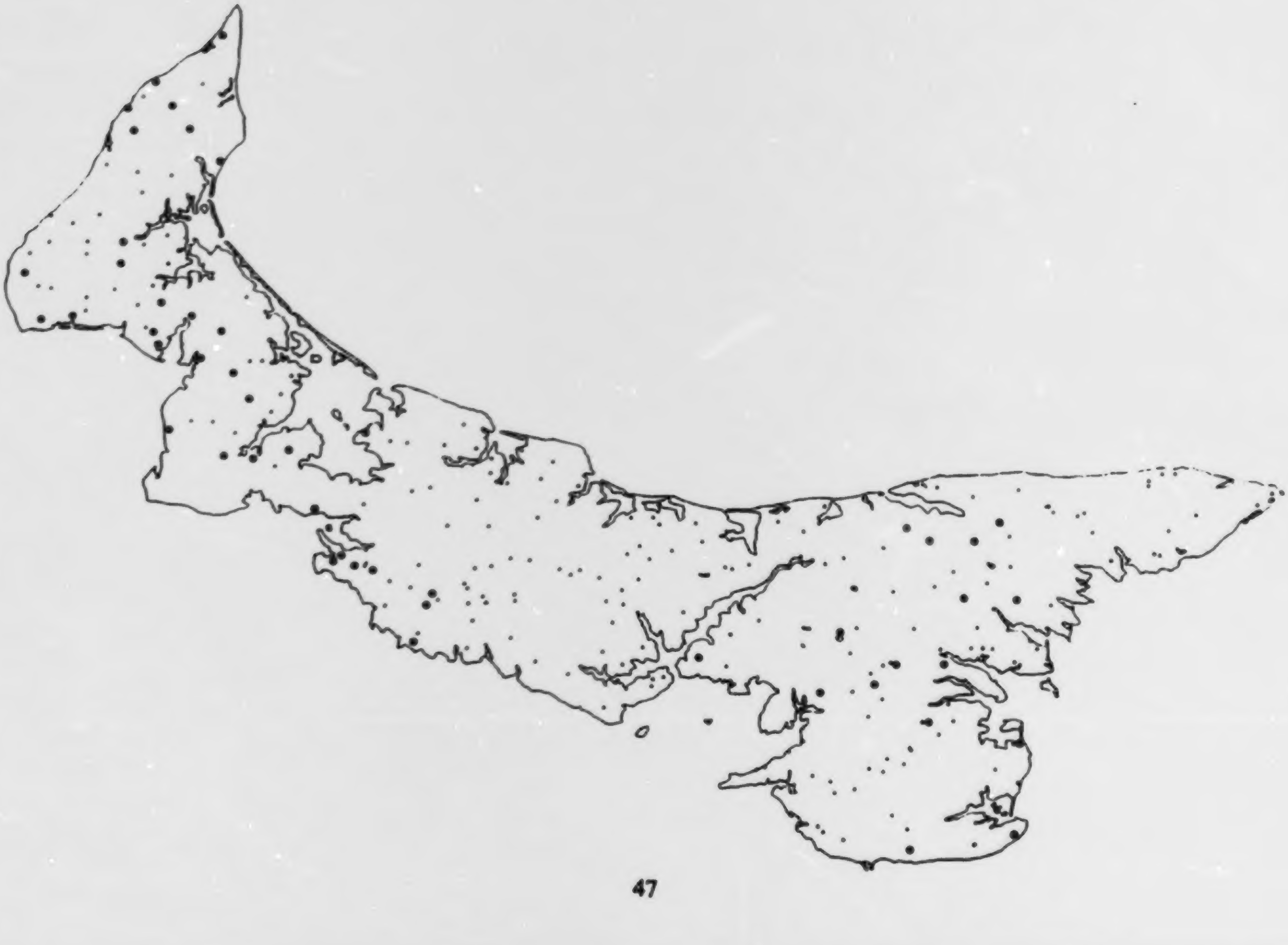
Stand Origin/History	*Status 1935*
$N^3\ SW^3\ PC^3\ OF^1$	$FC^9\ CL^1$

ENVIRONMENT

Geographical Distribution	*Distance to Coast (km)*	*Distance to Road (m)*	*Elevation (m)*	*Slope*
$W^5\ E^3\ C^2$	5.0 (*med*)	499 (*med*)	19.7 (*low*)	$L^8\ S^2$ (1.7°) (*low*)

Corn Heat Units	*Soil Series*	*Soil Texture*	*Soil Drainage*
2303 (*med*)	$Rp^2\ Wn^2\ Mp^1$	$LS^2\ O^2\ SIC^1\ SCL^1$	$P^6\ M^2\ I^1$

pH	*% O M*	*N : C (%)*	*P (ppm)*	*Ca (ppm)*
5.4 (*high*)	46 (*med*)	6.2 (*high*)	97 (*low*)	5930 (*high*)



GROUP 5

77 plots (6.8%)

GENERAL DESCRIPTION

A ground flora community-type of moderate occurrence, found especially in larger woodland areas at higher elevations more distant from the coast in parts of the central region, and in specific areas elsewhere. It is one of the three ground flora groups associated with hardwood forest on well-drained soils. The tree canopy is dominated by red maple, but has substantial components of the tolerant hardwood species especially sugar maple and yellow birch. The ground flora is species-poor, with two species (*Taxus canadensis* and *Dryopteris spinulosa*) predominating. Key site factors: higher elevation, sloping ground, well-drained soils, loams, Charlottetown and Alberry soil series, moderate organic matter, high N:C ratio, low level of past forest clearance, greater distance from roads/habitations. Key stand factors: hardwood-dominated, high stocking rate, the oldest and tallest trees of any group.

This group overlaps substantially with the other two tolerant hardwood ground flora groups (6 and 7), and slightly with Group 3. It shows a high spatial association with Group 6. It obviously falls within Erskine's upland tolerant hardwood forest type.

GROUND FLORA :

Mean taxa/plot = 5.6 ± 0.34 (S.E.) (*low*)

Total taxa recorded = 63

Taxa with frequency > 5% = 23

FREQUENT SPECIES (7 species) :

Dryopteris spinulosa, Taxus canadensis, Aralia nudicaulis, Maianthemum canadense, Trientalis borealis, Clintonia borealis, Cornus canadensis.

SELECTIVE SPECIES (4 species) :

Taxus canadensis, Dryopteris spinulosa, Acer spicatum, Oxalis montana.

TREES :

Mean taxa/plot = 3.6 ± 0.16 (S.E.) (***high***)

FREQUENT SPECIES : red maple, balsam fir, (sugar maple, yellow birch, white birch, white spruce)

DOMINANT SPECIES : red maple, (balsam fir, sugar maple, yellow birch)

SELECTIVE SPECIES : sugar maple, yellow birch, red maple, (striped maple, hemlock)

SHRUBS / SMALL TREES :

Mean taxa/plot = 1.7 ± 0.13 (S.E.) (*med*)

Mean total shrubs/plot = 5.8 ± 0.69 (S.E.) (*low*)

FREQUENT SPECIES : balsam fir, red maple, (sugar maple, mountain maple, yellow birch)

SELECTIVE SPECIES : mountain maple, striped maple, sugar maple, yellow birch, (red maple)

REGENERATION TREES :

Mean taxa/plot = 0.97 ± 0.11 (S.E.) (*med*)

Mean total plants/plot = 2.8 ± 0.62 (S.E.) (*low*)

FREQUENT SPECIES : balsam fir, (red maple, striped maple, sugar maple)

SELECTIVE SPECIES : sugar maple, striped maple

STAND & TREE PROPERTIES

Forest Type	*Woodland Size (km^2)*	*Stand Age*	*Stocking Class*
HH^{8}HS^1	5-10 km^2 *	U^4 M^4 I^2	4^9 3^1

% Biomass	*Tree Height (m)*	*Tree Age (yr)*	*Actual Density (%)*
H^8 S^2	16.3 *(high)*	67 *(high)*	91 *(high)*

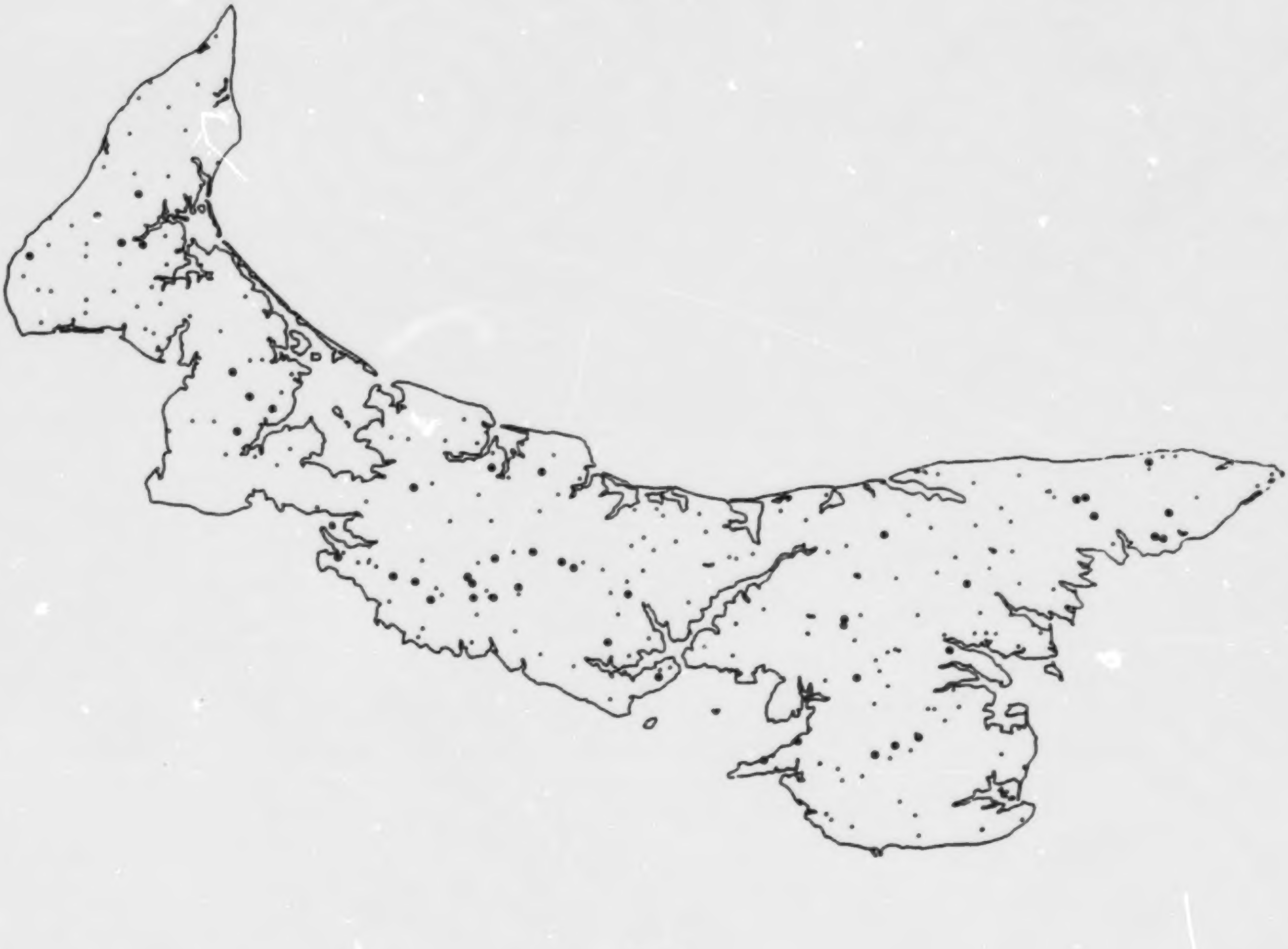
Stand Origin/History	*Status 1935*
N^3 PC^3 Bu^2 (OF^1)	FC^{10}

ENVIRONMENT

Geographical Distribution	*Distance to Coast (km)*	*Distance to Road (m)*	*Elevation (m)*	*Slope*
C^5 E^4 W^2	7.8 *(high)*	597 *(high)*	47.5 *(high)*	S^8 L^2(2.1°)*(med)*

Corn Heat Units	*Soil Series*	*Soil Texture*	*Soil Drainage*
2323 *(high)*	Ch^4 Al^3 Cu^1	L^4 SCL^2 SL^2	W^8 M^1

pH	*% OM*	*N : C (%)*	*P (ppm)*	*Ca (ppm)*
4.3 *(low)*	34 *(med)*	5.1 *(high)*	210 *(med)*	1200 *(low)*



GROUP 6

196 plots (17.4%)

GENERAL DESCRIPTION

A ground flora community-type of frequent occurrence, well-scattered throughout the central region and in the far west, and in specific areas elsewhere – especially in smaller woodland sizes. It is the largest of the three ground flora groups associated with hardwood forest on well-drained soils. The tree canopy is dominated by hardwoods, especially red maple, with a small contribution by the tolerant hardwood species, and there is also a notable softwood component. The ground flora is of moderate species-richness, and is characterised by eleven selective species. Key site factors: moderate elevation, sloping ground, well-drained soils, Charlottetown soil series, lowish organic matter, high N:C ratio, a greater level (than the other hardwood groups) of past forest clearance and cutting, smaller woodland size. Key stand factors: hardwood-dominated with intrusion of conifers.

This group overlaps substantially in species composition with the two other tolerant hardwood ground flora groups (5 and 7) - with both of which it shows a high spatial association. It falls within Erskine's upland tolerant hardwood forest, but appears to have been subjected to a greater level of past human exploitation than the other two hardwood groups.

GROUND FLORA :

Mean taxa/plot = 7.7 ± 0.23 (S.E.) (*med*)

Total taxa recorded = 110 Taxa with frequency > 5 % = 38

FREQUENT SPECIES (8 species) :

Maianthemum canadense, Trientalis borealis, Aralia nudicaulis, Dryopteris spinulosa, Clintonia borealis, Trillium undulatum, Viola pallens, Cornus canadensis.

SELECTIVE SPECIES (11 species) :

Trillium undulatum, Aralia nudicaulis, Cornus alternifolia, Aster acuminatus, Viola pallens, Clintonia borealis, Trientalis borealis, Viola incognita, Smilacina racemosa, Rubus canadensis, Dryopteris spinulosa.

TREES :

Mean taxa/plot = 3.6 ± 0.09 (S.E.) (*high*)

FREQUENT SPECIES : balsam fir, red maple, (white birch, white spruce, sugar maple, yellow birch)

DOMINANT SPECIES : red maple, (balsam fir, white spruce)

SELECTIVE SPECIES : beech, sugar maple, white birch, red maple, (yellow birch)

SHRUBS / SMALL TREES :

Mean taxa/plot = 2.0 ± 0.09 (S.E.) (*high*) Mean total shrubs/plot = 7.1 ± 0.50 (S.E.) (*low*)

FREQUENT SPECIES : balsam fir, red maple, (white birch, sugar maple, white spruce, pin cherry)

SELECTIVE SPECIES : balsam fir, (striped maple, yellow birch, white birch, red maple)

REGENERATION TREES :

Mean taxa/plot = 1.4 ± 0.084 (S.E.) (*high*) Mean total plants/plot = 5.7 ± 0.62 (S.E.) (*high*)

FREQUENT SPECIES : balsam fir, red maple, (sugar maple, striped maple)

SELECTIVE SPECIES : sugar maple, balsam fir, striped maple, (yellow birch)

STAND & TREE PROPERTIES

Forest Type	*Woodland Size (km^2)*	*Stand Age*	*Stocking Class*
HH^5 HS^3 SH^1	≤5 km^2 *	M^4 U^3 I^3	4^7 3^3

% Biomass	*Tree Height (m)*	*Tree Age (yr)*	*Actual Density (%)*
H^6 S^4	15.6 *(high)*	57 *(med)*	82 *(high)*

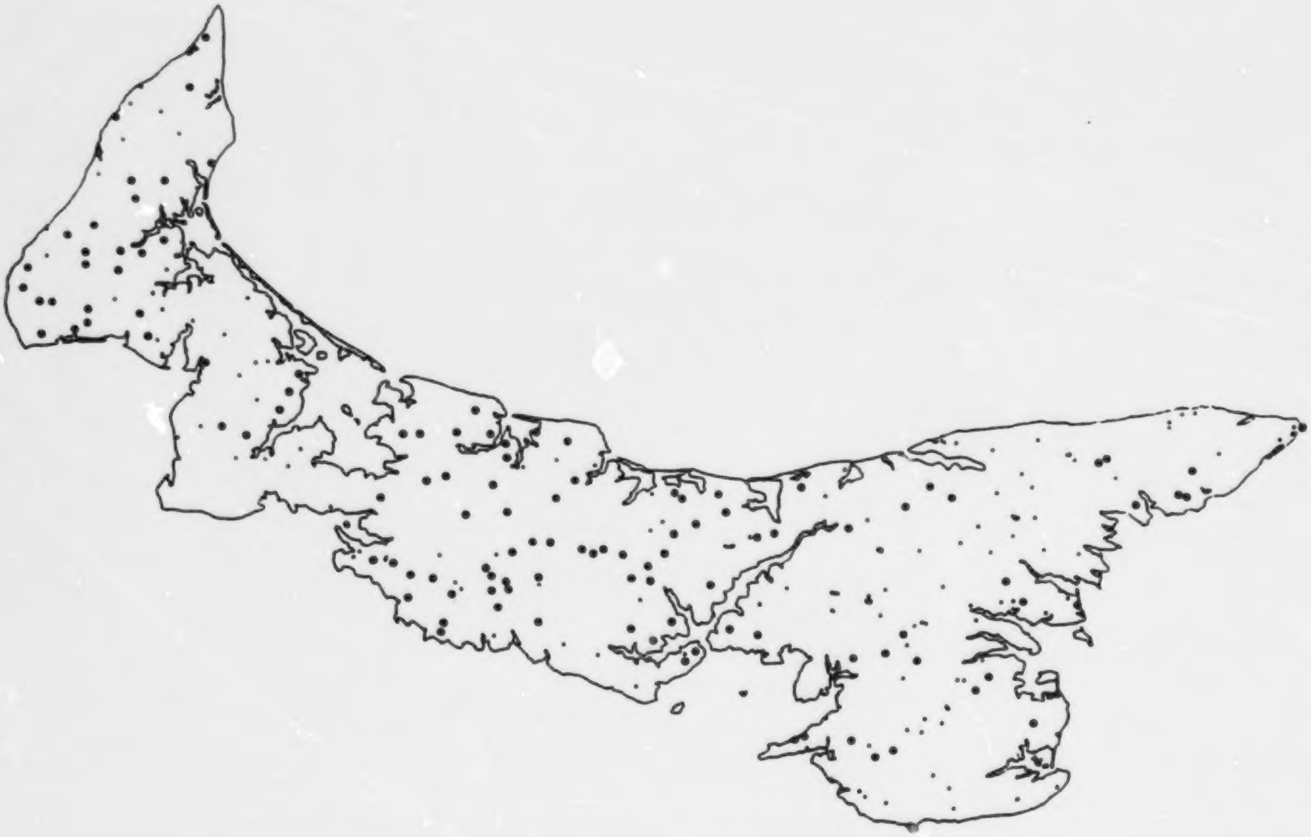
Stand Origin/History	*Status 1935*
PC^3 N^3 OF^2 (CC^1)	FC^9 CL^1

ENVIRONMENT

Geographical Distribution	*Distance to Coast (km)*	*Distance to Road (m)*	*Elevation (m)*	*Slope*
C^5 E^2 W^2	5.7 *(med)*	491 *(med)*	36.9 *(med)*	S^7 L^3 (2.5°) *(high)*

Corn Heat Units	*Soil Series*	*Soil Texture*	*Soil Drainage*
2321 *(high)*	Ch^5 Al^2 Cu^1	L^3 SCL^3 SL^2	W^9 M^1

pH	*% O M*	*N : C (%)*	*P (ppm)*	*Ca (ppm)*
4.3 *(low)*	23 *(low)*	5.4 *(high)*	170 *(med)*	890 *(low)*



GROUP 7

155 plots (13.8%)

GENERAL DESCRIPTION

A ground flora community-type of frequent occurrence, scattered throughout the central region and in specific areas elsewhere notably at points of higher elevation more distant from the coast. It is the third of the three ground flora groups associated with hardwood forest on well-drained soils. Its tree canopy is dominated by red maple, with a notable contribution by the tolerant hardwoods – especially sugar maple and beech. The ground flora is of moderate species-richness, with nine species selective for the group. Key site factors: higher elevation, sloping ground, well-drained soils, Charlottetown soil series, lowish organic matter, high N:C ratio, small to moderate woodland size, lowish level of past forest clearance. Key stand factors : hardwood-dominated, highish stocking rate.

This group overlaps substantially in species composition with the other two tolerant hardwood ground flora groups (5 and 7), and shows a high spatial association with Group 6. It falls within Erskine's upland tolerant hardwood forest.

GROUND FLORA :

Mean taxa/plot = 6.9 ± 0.20 (S.E.) (*low*)

Total taxa recorded = 78　　Taxa with frequency > 5% = 28

FREQUENT SPECIES (7 species) :

Maianthemum canadense, Dennstaedtia punctilobula, Lycopodium obscurum, Trientalis borealis, Aralia nudicaulis, Trillium undulatum, Dryopteris spinulosa

SELECTIVE SPECIES (9 species) :

Dennstaedtia punctilobula, Lycopodium obscurum, Lycopodium annotinum, Trillium undulatum, Medeola virginiana, Lycopodium lucidulum, Smilacina racemosa, Monotropa uniflora, Trientalis borealis.

TREES :

Mean taxa/plot = 3.6 ± 0.10 (S.E.) (*high*)

FREQUENT SPECIES :	red maple, balsam fir, (white birch, sugar maple, yellow birch, white spruce)
DOMINANT SPECIES :	red maple, (balsam fir, white birch)
SELECTIVE SPECIES :	sugar maple, beech, red maple, yellow birch, white birch

SHRUBS / SMALL TREES :

Mean taxa/plot = 1.8 ± 0.09 (S.E.) (*med*)　　Mean total shrubs/plot = 6.3 ± 0.51 (S.E.) (*low*)

FREQUENT SPECIES :	balsam fir, red maple, sugar maple, (white spruce, beech)
SELECTIVE SPECIES :	sugar maple, beech, red maple, (balsam fir)

REGENERATION TREES :

Mean taxa/plot = 1.2 ± 0.084 (S.E.) (*med*)　　Mean total plants/plot = 4.6 ± 0.64 (S.E.) (*med*)

FREQUENT SPECIES :	balsam fir, (striped maple, red maple, sugar maple)
SELECTIVE SPECIES :	striped maple, sugar maple, beech, (balsam fir)

STAND & TREE PROPERTIES

Forest Type	*Woodland Size (km²)*	*Stand Age*	*Stocking Class*
HH^7 HS^2	≤5 km^2 *	I^4 U^3 M^3	4^8 3^2

% Biomass	*Tree Height (m)*	*Tree Age (yr)*	*Actual Density (%)*
H^8 S^2	15.2 *(high)*	57 *(med)*	89 *(high)*

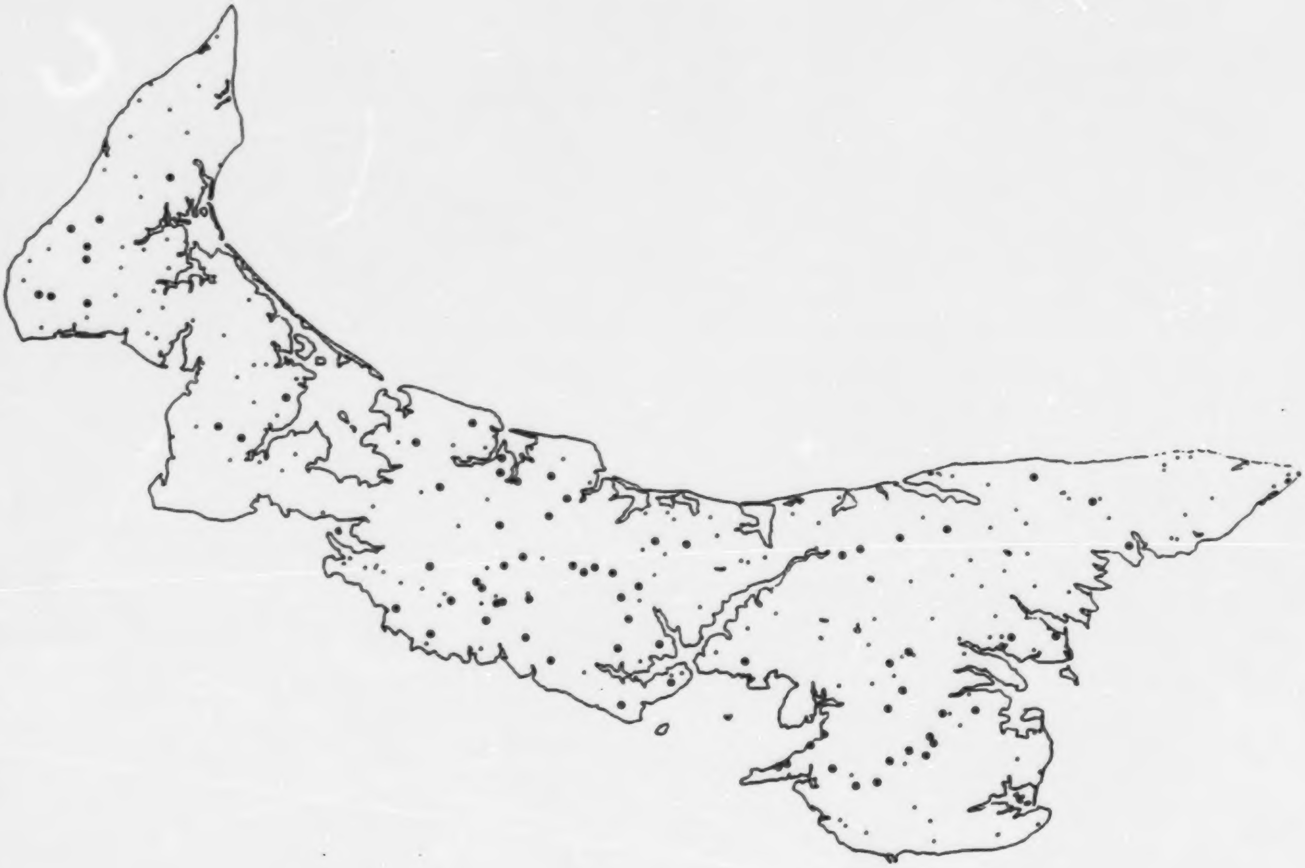
Stand Origin/History	*Status 1935*
N^4 PC^3 Bu^2	FC^9 CL^1

ENVIRONMENT

Geographical Distribution	*Distance to Coast (km)*	*Distance to Road (m)*	*Elevation (m)*	*Slope*
C^5 E^3 W^1	7.6 *(high)*	477 *(med)*	50.3 *(high)*	S^8 L^2 (2.4°) *(high)*

Corn Heat Units	*Soil Series*	*Soil Texture*	*Soil Drainage*
2325 *(high)*	Ch^6 Al^2 Cu^1	SCL^3 L^3 SL^2 CL^2	W^9 M^1

pH	*% O M*	*N : C (%)*	*P (ppm)*	*Ca (ppm)*
4.2 *(low)*	21 *(low)*	5.0 *(high)*	180 *(med)*	530 *(low)*



GROUP 8

165 plots (14.6%)

GENERAL DESCRIPTION

A ground flora community-type of frequent occurrence, especially common in larger woodland areas at moderately low elevations in the east and in the far west. It is associated with conifer-dominated forest on soils of varying drainage properties – though not on the wettest. The tree canopy is dominated by softwoods, especially balsam fir, with white spruce. The ground flora is of moderate species-richness, with thirteen species selective for the group. Key site factors: highish level of partial-cutting/thinning, highish level of past forest clearance, generally good drainage, moderate soil nutrient levels. Key stand factors : softwood-dominated, moderate stocking rate.

This group is very similar in species composition to Group 9 – with which it also shows a significant spatial association. It is difficult to equate it with any of Erskine's climax forest types – it appears rather to be a successional community heavily affected by past and continuing human exploitation.

GROUND FLORA :

Mean taxa/plot = 9.8 ± 0.29 (S.E.) (*med*)

Total taxa recorded = 94 Taxa with frequency > 5% = 37

FREQUENT SPECIES (9 species) :

Maianthemum canadense, Pleurozium schreberi, Viburnum cassinoides, Cornus canadensis, Trientalis borealis, Aralia nudicaulis, Clintonia borealis, Dicranum scoparium, Linnaea borealis.

SELECTIVE SPECIES (13 species) :

Linnaea borealis, Viburnum cassinoides, Clintonia borealis, Dicranum scoparium, Pleurozium schreberi, Cornus canadensis, Nemopanthus mucronata, Hylocomium splendens, Coptis groenlandicum , Maianthemum canadense, Dicranum polysetum, Aralia nudicaulis, Bazzania trilobata.

TREES :

Mean taxa/plot = 3.4 ± 0.10 (S.E.) (*high*)

FREQUENT SPECIES :	balsam fir, red maple, white spruce, (white birch, trembling aspen)
DOMINANT SPECIES :	balsam fir, red maple, (white spruce)
SELECTIVE SPECIES :	(balsam fir)

SHRUBS / SMALL TREES :

Mean taxa/plot = 1.9 ± 0.09 (S.E.) (*med*) Mean total shrubs/plot = 8.0 ± 0.69 (S.E.) (*med*)

FREQUENT SPECIES :	balsam fir, red maple, (white spruce, *Virburnum cassinoides*, pin cherry, white birch)
SELECTIVE SPECIES :	balsam fir

REGENERATION TREES :

Mean taxa/plot = 1.2 ± 0.087 (S.E.) (*med*) Mean total plants/plot = 5.4 ± 0.69 (S.E.) (*high*)

FREQUENT SPECIES :	balsam fir, red maple
SELECTIVE SPECIES :	balsam fir

STAND & TREE PROPERTIES

Forest Type	*Woodland Size (km^2)*	*Stand Age*	*Stocking Class*
HS^4 SH^3 HH^2	>10 km^2 *	M^5 I^3 U^2	4^7 3^3

% Biomass	*Tree Height (m)*	*Tree Age (yr)*	*Actual Density (%)*
S^6 H^4	15.0 *(high)*	56 *(med)*	75 *(med)*

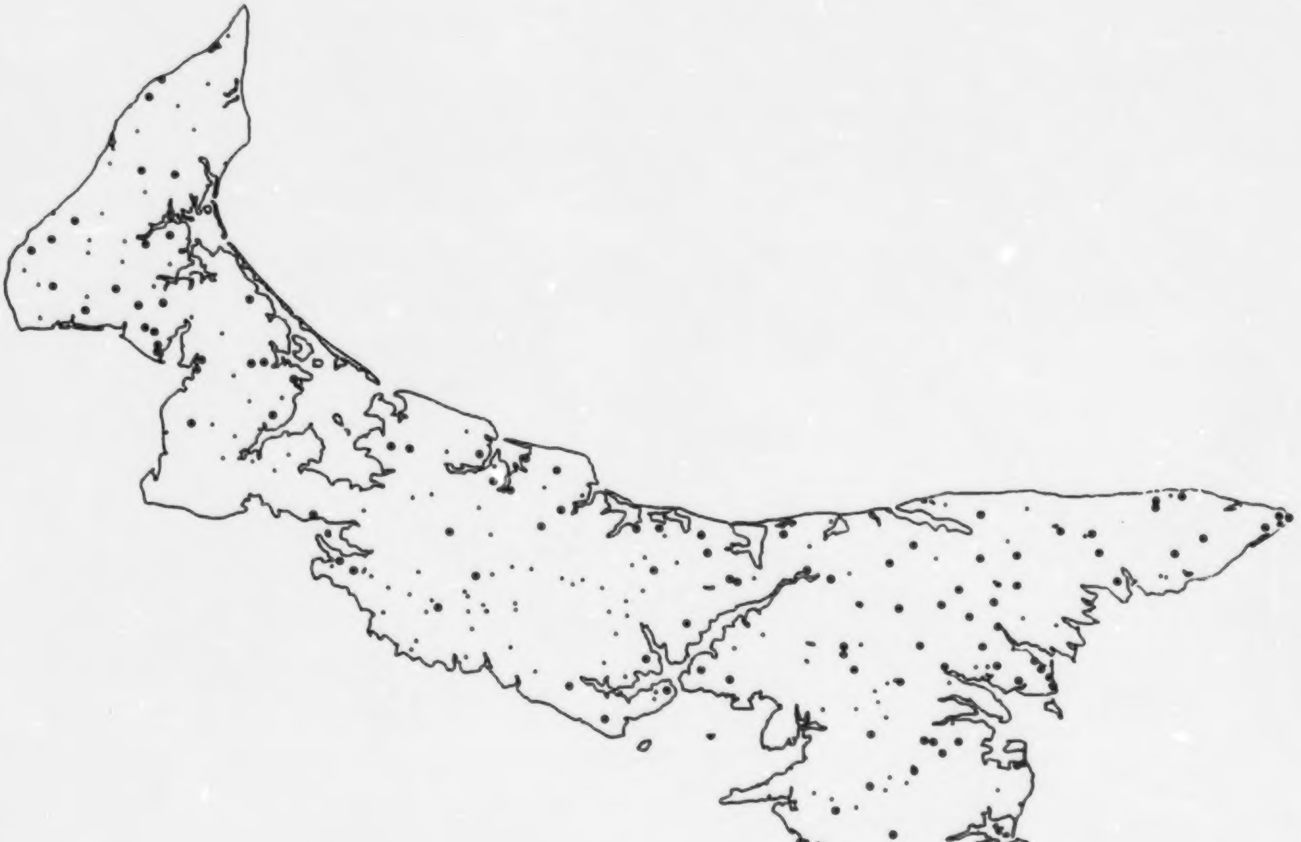
Stand Origin/History	*Status 1935*
PC^4 N^3 OF^2	FC^9 CL^1

ENVIRONMENT

Geographical Distribution	*Distance to Coast (km)*	*Distance to Road (m)*	*Elevation (m)*	*Slope*
E^5 W^2 C^2	5.3 *(med)*	471 *(med)*	28.0 *(low)*	S^7 L^2 (1.7°) *(med)*

Corn Heat Units	*Soil Series*	*Soil Texture*	*Soil Drainage*
2302 *(med)*	Ch^2 Al^2 Cu^1 Ma^1 Bp^1	L^3 SCL^2 SL^2 CL^2	W^6 I^2 M^2

pH	*% O M*	*N : C (%)*	*P (ppm)*	*Ca (ppm)*
4.2 *(low)*	40 *(med)*	4.5 *(med)*	240 *(high)*	1200 *(low)*



GROUP 9

118 plots (10.5%)

GENERAL DESCRIPTION

A ground flora community-type of common occurrence, especially in larger woodland areas at lower elevations in the east and in the far west. It is associated with conifer-dominated forest on the dryer soils. The tree canopy is dominated by softwoods, especially balsam fir, with white, black and red spruce. The ground flora is of moderate species-richness, with thirteen taxa selective for the group. Key site factors : well or moderately well-drained soils, Culloden soil series, moderate soil nutrient levels, highish level of partial-cutting/thinning, highish level of past forest clearance. Key stand factors : softwood-dominated, moderate stocking rate.

This group is very similar in species composition to Group 8, with which it also shows a significant spatial association – though it appears to occur on drier soils than that group. Like Group 8, it appears to correspond to a successional forest type on dry soils, heavily affected by past and continuing human exploitation.

GROUND FLORA :

Mean taxa/plot = 9.5 ± 0.27 (S.E.) (*med*)

Total taxa recorded = 89

Taxa with frequency > 5% = 35

FREQUENT SPECIES (10 species) :

Maianthemum canadense, Cornus canadensis, Pteridium aquilinum, Pleurozium schreberi, Viburnum cassinoides, Trientalis borealis, Vaccinium angustifolium, Kalmia angustifolia, Polytrichum commune, Vaccinium myrtilloides.

SELECTIVE SPECIES (12 species) :

Pteridium aquilinum, Vaccinium angustifolium, Kalmia angustifolia, Cornus canadensis, Vaccinium mytilloides, Viburnum cassinoides, Epigaea repens, Pleurozium schreberi, Polytrichum commune, Linnaea borealis, Maianthemum canadense, Amelanchier spp.

TREES :

Mean taxa/plot = 3.2 ± 0.11 (S.E.) (*high*)

FREQUENT SPECIES : balsam fir, white spruce, (red maple, trembling aspen, black spruce, red spruce)

DOMINANT SPECIES : balsam fir, (white spruce, red maple, black spruce, red spruce)

SELECTIVE SPECIES : red spruce, black spruce, white pine, (trembling aspen)

SHRUBS / SMALL TREES :

Mean taxa/plot = 2.3 ± 0.13 (S.E.) (*high*)

Mean total shrubs/plot = 9.1 ± 0.85 (S.E.) (*high*)

FREQUENT SPECIES : balsam fir, red maple, *Virburnum cassinoides*, (white spruce, pin cherry, white birch, red spruce, trembling aspen, black spruce)

SELECTIVE SPECIES : *Nemopanthus mucronata, Viburnum cassinoides*, red spruce, (pin cherry, balsam fir, trembling aspen, grey birch)

REGENERATION TREES :

Mean taxa/plot = 1.1 ± 0.081 (S.E.) (*med*)

Mean total plants/plot = 3.5 ± 0.44 (S.E.) (*low*)

FREQUENT SPECIES : red maple, balsam fir

SELECTIVE SPECIES : red spruce

STAND & TREE PROPERTIES

Forest Type	*Woodland Size (km^2)*	*Stand Age*	*Stocking Class*
SH^4 HS^3 SS^2	>10 km^2 *	U^4 M^3 I^3	4^5 3^4 2^1

% Biomass	*Tree Height (m)*	*Tree Age (yr)*	*Actual Density (%)*
S^7 H^3	14.3 *(med)*	54 *(med)*	67 *(med)*

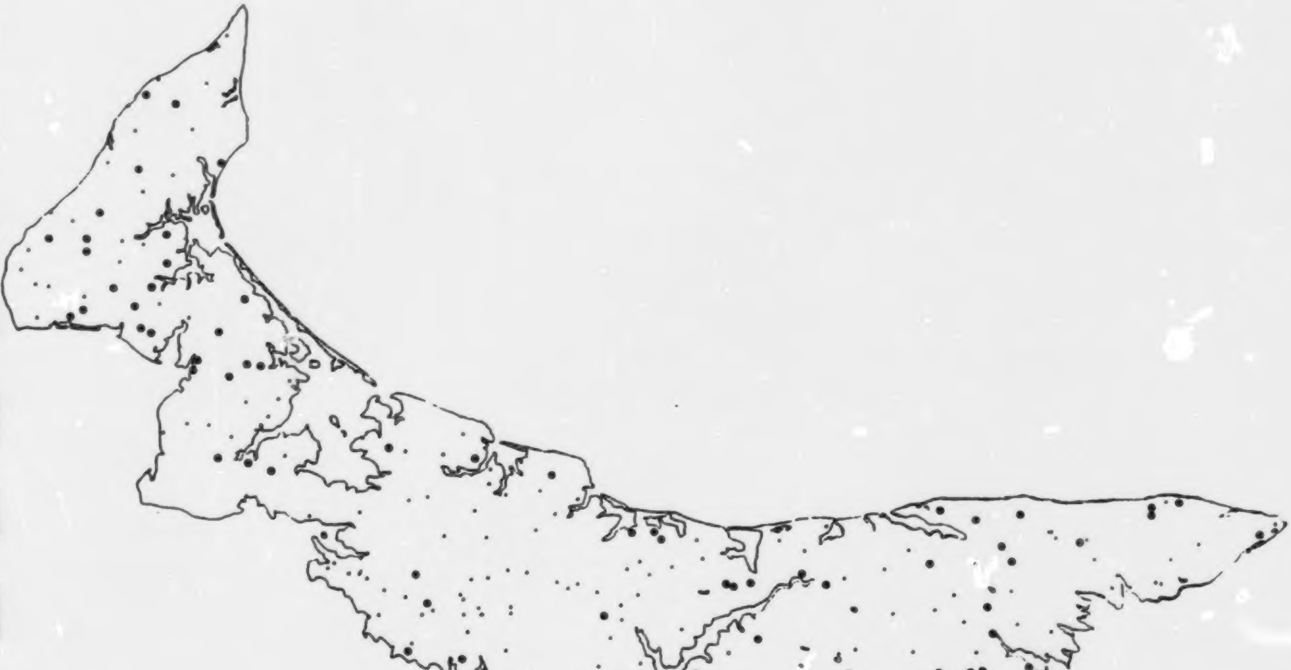
Stand Origin/History	*Status 1935*
PC^4 N^3 OF^1	FC^8 CL^2

ENVIRONMENT

Geographical Distribution	*Distance to Coast (km)*	*Distance to Road (m)*	*Elevation (m)*	*Slope*
E^5 W^3 C^1	5.2 *(med)*	522 *(high)*	21.7 *(low)*	S^5 L^5 (1.5°) *(med)*

Corn Heat Units	*Soil Series*	*Soil Texture*	*Soil Drainage*
2305 *(med)*	Cu^2 Ch^2 Al^1 Mg^1	SCL^3 SL^2 L^2 CL^2	W^5 M^4

pH	*% O M*	*N : C (%)*	*P (ppm)*	*Ca (ppm)*
4.0 *(low)*	37 *(med)*	4.4 *(med)*	200 *(med)*	830 *(low)*



GROUP 10

135 plots (12.0%)

GENERAL DESCRIPTION

A ground flora community-type of common occurrence in woodlands of varying sizes on well drained soils at moderate elevations, with a distinct bias toward the eastern end of the island. This group is largely associated with white spruce woods on land formerly cleared for agriculture. The tree canopy is dominated by a single species – white spruce, which is generally youngish and even-aged, and of high density. It is a species-poor community at all levels (i.e. in ground flora, shrubs and trees), characterised by only seven selective taxa, most of which are either mosses or weedy aliens. Key site factors : 'old field' sites (ie. formerly cleared land), well-drained soils, Culloden soil series, sloping land, lowish organic matter content. Key stand factors : white spruce-dominated, immature, of low age and height, high stocking rate.

This group is dissimilar in species composition to all other groups and has no notable spatial association with the other groups. It corresponds to Erskine's old field white spruce woods.

GROUND FLORA :

Mean taxa/plot = 6.5 ± 0.29 (S.E.) (*low*)

Total taxa recorded = 94 — Taxa with Frequency > 5% = 36

FREQUENT SPECIES (6 species) :

Pleurozium schreberi, Maianthemum canadense, Polytrichum commune, Trientalis borealis, Vaccinium angustifolium, Carex spp..

SELECTIVE SPECIES (7 species) :

Pleurozium schreberi, Hieracium aurantiacum, Polytrichum commune, Ptilium crista-castrensis, Veronica officinalis, Aster spp., Myrica pensylvanica.

TREES :

Mean taxa/plot = 2.4 ± 0.11 (S.E.) (*low*)

FREQUENT SPECIES :	white spruce, (balsam fir, white birch)
DOMINANT SPECIES :	white spruce
SELECTIVE SPECIES :	white spruce

SHRUBS / SMALL TREES :

Mean taxa/plot = 1.4 ± 0.08 (S.E.) (*low*) — Mean total shrubs/plot = 7.7 ± 0.81 (S.E.) (*med*)

FREQUENT SPECIES :	white spruce, balsam fir, (pin cherry)
SELECTIVE SPECIES :	white spruce

REGENERATION TREES :

Mean taxa/plot = 0.77 ± 0.082 (S.E.) (*low*) — Mean total plants/plot = 2.9 ± 0.44 (S.E.) (*low*)

FREQUENT SPECIES :	(balsam fir, red maple)
SELECTIVE SPECIES :	none

STAND & TREE PROPERTIES

Forest Type	*Woodland Size (km^2)*	*Stand Age*	*Stocking Class*
SS^5 SH^3 HS^1	≤5 km^2	I^4 M^4 U^2	4^7 3^2 2^1

% Biomass	*Tree Height (m)*	*Tree Age (yr)*	*Actual Density (%)*
S^8 H^2	14.9 *(med)*	44 *(low)*	83 *(high)*

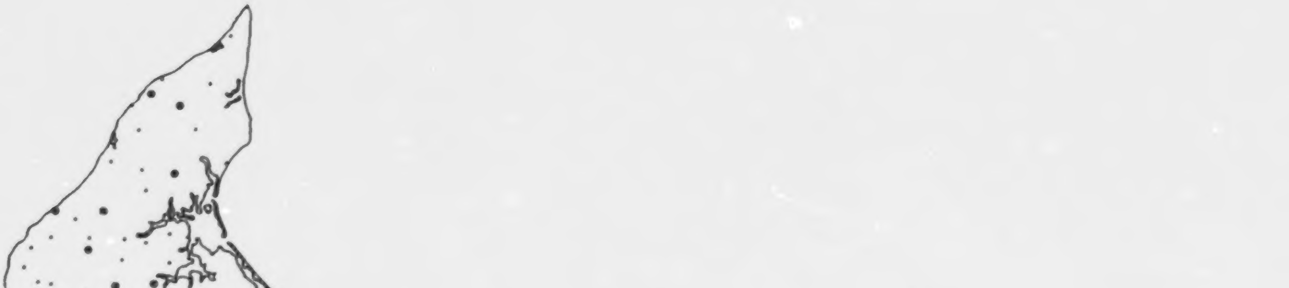
Stand Origin/History	*Status 1935*
OF^6 PC^2 N^1	CL^7 FC^3

ENVIRONMENT

Geographical Distribution	*Distance to Coast (km)*	*Distance to Road (m)*	*Elevation (m)*	*Slope*
E^6 C^3 W^1	6.7 *(high)*	379 *(low)*	36.1 *(med)*	S^8 L^2 (1.9°) *(med)*

Corn Heat Units	*Soil Series*	*Soil Texture*	*Soil Drainage*
2308 *(med)*	Ch^4 Cu^3 Al^1	L^3 SCL^2 SL^2	W^8 M^1

pH	*% O M*	*N : C (%)*	*P (ppm)*	*Ca (ppm)*
4.2 *(low)*	24 *(low)*	4.6 *(med)*	180 *(med)*	640 *(low)*



GROUP 11

21 plots (1.9%)

GENERAL DESCRIPTION

A ground flora community-type occurring at only a few sites usually on well-drained soils at higher elevations scattered about the island. Its tree canopy is a mixture of hardwoods and conifers, with balsam fir and white spruce predominating, but with a notable contribution by beech. The ground flora is very species-poor, with only one species selective for the group. Key site factors : sloping ground, well-drained soils, Alberry soil series, lowish organic matter, moderate N:C ratio. Key stand factors : high stocking rate, high tree height.

This group shows some similarities in species composition to the hardwood Group 7, and appears to be a small group of plots that got separated from the other hardwood groups in the first TWINSPAN division – probably because of its species-poorness. However, its only significant spatial association is with Group 10. It is on too small a scale to have any correspondence with any of Erskine's groups.

GROUND FLORA :

Mean taxa/plot = 4.0 ± 0.44 (S.E.) (*low*)

Total taxa recorded = 22 Taxa with Frequency > 5% = 10

FREQUENT SPECIES (5 species) :

Dicranum scoparium, Pleurozium schreberi, Maianthemum canadense, Trientalis borealis, Polytrichum commune.

SELECTIVE SPECIES (1 species) :

Dicranum scoparium.

TREES :

Mean taxa/plot = 3.4 ± 0.30 (S.E.) (*high*)

FREQUENT SPECIES :	balsam fir, white birch, white spruce, (trembling aspen, yellow birch, red maple)
DOMINANT SPECIES :	balsam fir, white spruce, (white birch, beech)
SELECTIVE SPECIES :	none

SHRUBS / SMALL TREES :

Mean taxa/plot = 2.0 ± 0.26 (S.E.) (*high*) Mean total shrubs/plot = 7.6 ± 1.5 (S.E.) (*med*)

FREQUENT SPECIES :	balsam fir, white spruce, white birch, (red maple, beech, pin cherry, trembling aspen)
SELECTIVE SPECIES :	(white spruce, beech, white birch)

REGENERATION TREES :

Mean taxa/plot = 1.0 ± 0.20 (S.E.) (*med*) Mean total plants/plot = 4.3 ± 1.9 (S.E.) (*med*)

FREQUENT SPECIES :	balsam fir, trembling aspen, (white spruce)
SELECTIVE SPECIES :	trembling aspen

STAND & TREE PROPERTIES

Forest Type	*Woodland Size (km^2)*	*Stand Age*	*Stocking Class*
HH^6 HS^2 SH^1	>10 km^2	M^5 I^3 U^2	4^9 3^1

% Biomass	*Tree Height (m)*	*Tree Age (yr)*	*Actual Density (%)*
S^5 H^5	15.3 *(high)*	53 *(med)*	89 *(high)*

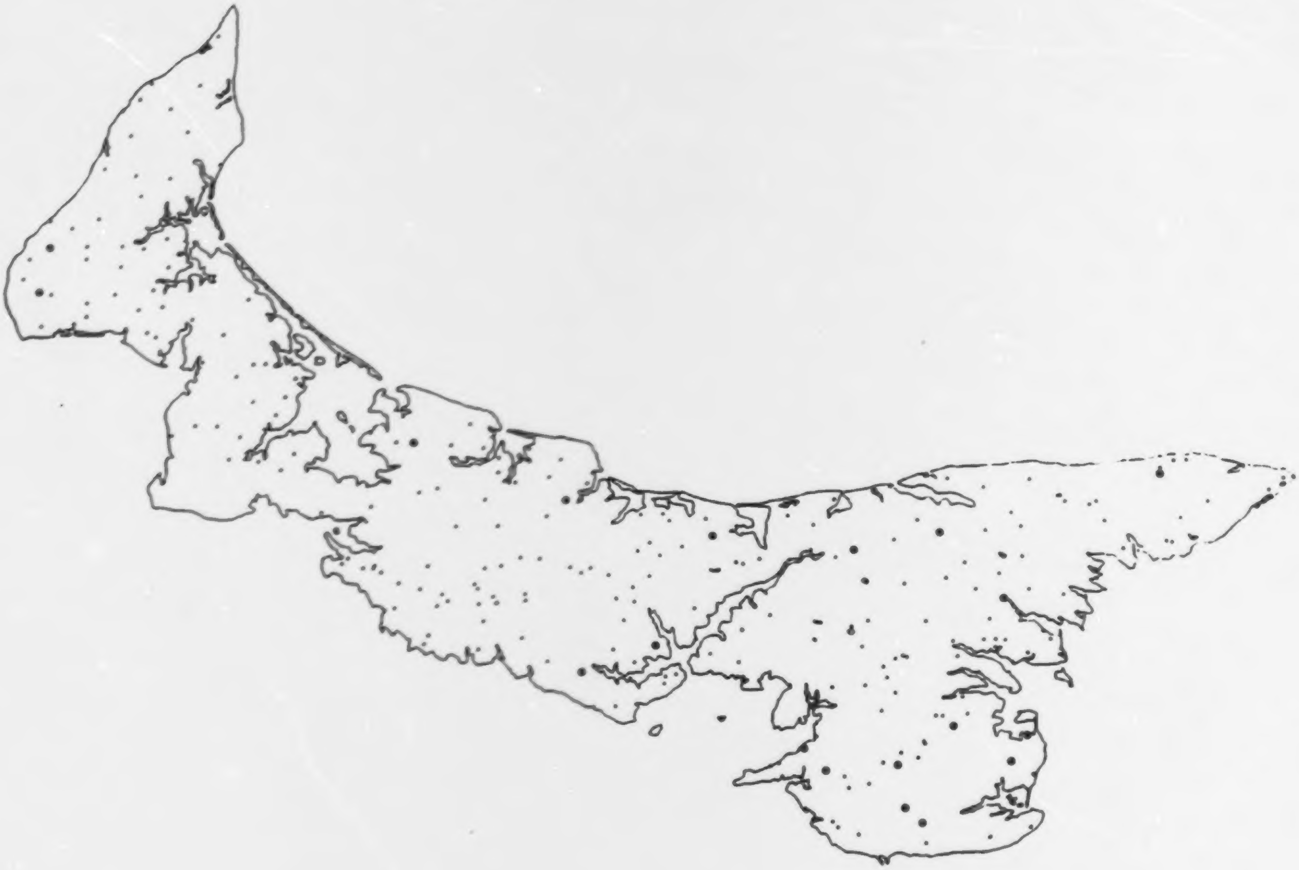
Stand Origin/History	*Status 1935*
PC^4 OF^2 Bu^2	FC^7 CL^3

ENVIRONMENT

Geographical Distribution	*Distance to Coast (km)*	*Distance to Road (m)*	*Elevation (m)*	*Slope*
E^6 C^3 W^1	5.6 *(med)*	495 *(med)*	42.2 *(high)*	S^9 L^1 (2.0°) *(med)*

Corn Heat Units	*Soil Series*	*Soil Texture*	*Soil Drainage*
2311 *(med)*	Al^4 Ch^4 Cu^1	LS^4 L^3 CL^2	W^9 M^1

pH	*% O M*	*N : C (%)*	*P (ppm)*	*Ca (ppm)*
4.4 *(low)*	27 *(low)*	4.9 *(med)*	270 *(high)*	760 *(low)*



GROUP 12

12 plots (1.1%)

GENERAL DESCRIPTION

A ground flora community-type occurring at only a few sites, mostly poorly drained and at lower elevations in the eastern part of the island. Its tree canopy consists of a mixture of conifers and hardwoods, with red maple making the greatest contribution, followed by balsam fir and black spruce. The ground flora is very species-rich, as is also the tree, shrub and regeneration tree component. Eleven ground flora taxa are selective for the group. Key site factors : level ground, poor drainage, organic soils, swamp characteristics, soils of high base and nutrient status. Key stand factors : lowish stocking rate.

This small group shares many of its tree and ground flora species with Groups 3 and 13 and appears in some respects to be transitional between them. If it corresponds at all to any of Erskine's communities, it is likely to be a type transitional between his lowland red maple forest and his lowland black spruce forest.

GROUND FLORA :

Mean taxa/plot = 13.9 ± 2.2 (S.E.) (*high*)

Total taxa recorded = 55

Taxa with frequency > 5% = 55

FREQUENT SPECIES (23 species) :

Sphagnum spp., Cornus canadensis, Osmunda cinnamomea, Pleurozium schreberi, Virburnum cassinoides, Carex spp., Hylocomium splendens, Kalmia angustifolia, Smilacina trifolia, Coptis groenlandica, Rubus pubescens, Nemopanthus mucronata, Dryopteris cristata, Maianthemum canadense, Trientalis borealis, Viola spp., Alnus rugosa, Fragaria virginiana, Impatiens capensis, Ilex verticillata, Pteridium aquilinum, Rhytiadelphus triquetrus, Vaccinium angustifolium.

SELECTIVE SPECIES (11 species) :

Smilacina trifolia, Osmunda cinnamomea, Sphagnum spp., Dryopteris cristata, Hylocomium splendens, Ilex verticillata, Viola spp., Kalmia angustifolia, Coptis groenlandica, Alnus rugosa, Nemopanthus mucronata.

TREES :

Mean taxa/plot = 3.2 ± 0.37 (S.E.) (*high*)

FREQUENT SPECIES : black spruce, red maple, balsam fir, larch

DOMINANT SPECIES : red maple, (balsam fir, black spruce, red spruce)

SELECTIVE SPECIES : black spruce, larch

SHRUBS / SMALL TREES :

Mean taxa/plot = 2.3 ± 0.28 (S.E.) (*high*)

Mean total shrubs/plot = 10.5 ± 2.8 (S.E.) (*high*)

FREQUENT SPECIES : balsam fir, black spruce, alder, (red maple, *Ilex verticillata*, *Nemopanthus mucronata*)

SELECTIVE SPECIES : black spruce, (*Ilex verticillata*)

REGENERATION TREES :

Mean taxa/plot = 1.5 ± 0.29 (S.E.) (*high*)

Mean total plants/plot = 3.2 ± 0.74 (S.E.) (*low*)

FREQUENT SPECIES : red maple, balsam fir, (larch)

SELECTIVE SPECIES : larch, (red maple)

STAND & TREE PROPERTIES

Forest Type	*Woodland Size (km²)*	*Stand Age*	*Stocking Class*
$HH^3\ SS^3\ SH^2$	>10 km²	$M^6\ O^2\ U^2$	$3^5\ 4^2\ 2^2$

% Biomass	*Tree Height (m)*	*Tree Age (yr)*	*Actual Density (%)*
$S^7\ H^3$	13.5 *(med)*	68 *(high)*	50 *(low)*

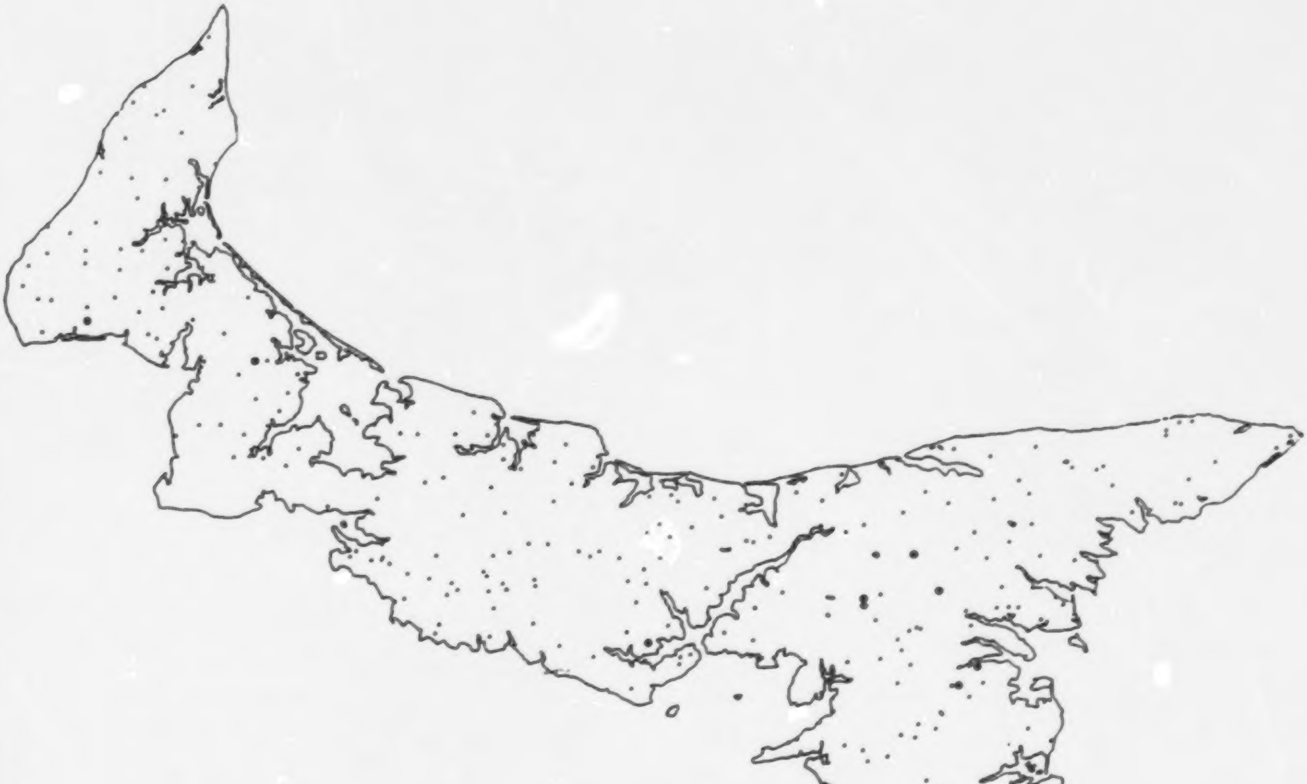
Stand Origin/History	*Status 1935*
$SW^7\ PC^2\ BOG^1$	FC^{10}

ENVIRONMENT

Geographical Distribution	*Distance to Coast (km)*	*Distance to Road (m)*	*Elevation (m)*	*Slope*
$E^7\ C^2\ W^2$	7.7 *(high)*	392 *(low)*	25.2 *(low)*	$L^8\ S^2$ (1.[illegible]°) *(low)*

Corn Heat Units	*Soil Series*	*Soil Texture*	*Soil Drainage*
2306 *(med)*	$Ch^2\ Mg^2\ Wn^2$	O^4	$P^7\ I^2\ M^1$

pH	*% O M*	*N : C (%)*	*P (ppm)*	*Ca (ppm)*
4.9 *(high)*	65 *(high)*	4.6 *(med)*	120 *(low)*	4100 *(high)*



GROUP 13

29 plots (2.6%)

GENERAL DESCRIPTION

A rather uncommon ground flora community-type occurring in scattered clusters in all three regions of the island – usually at poorly drained sites at lower elevations. The tree canopy is dominated by conifers, above all black spruce, with some larch and red spruce. The ground flora is of moderate species-richness, with ten taxa selective for the group. Key site factors : level ground, poorly-drained soils, Mossy Point, Orwell and Winsloe soil series, organic soil parent materials, swamp and bog characteristics, low base status, low nutrient content. Key stand factors : black spruce-dominated, low stocking rate, low tree height, medium tree age.

This group shows extensive overlap in species composition with Group 14 (with which it also shows a significant spatial association), and to a lesser extent with Group 12. It corresponds to Erskine's lowland black spruce swamp forest type.

GROUND FLORA :

Mean taxa/plot = 8.9 ± 0.60 (S.E.) (*med*)

Total taxa recorded = 43   Taxa with frequency > 5% = 32

FREQUENT SPECIES (14 species) :

Sphagnum spp., Nemopanthus mucronata, Pleurozium schreberi, Kalmia angustifolia, Cornus canadensis, Carex spp., Viburnum cassinoides, Gaultheria hispidula, Cypripedium acaule, Vaccinium myrtilloides, Ledum groenlandicum, Clintonia borealis, Cladina rangiferina, Polytrichum commune.

SELECTIVE SPECIES (10 species) :

Sphagnum spp., Nemopanthus mucronata, Gaultheria hispidula, Cypripedium acaule, Ledum groenlandicum, Gaylussacia baccata, Chamaedaphne calyculata, Kalmia angustifolia, Smilacina trifolia, Vaccinium myrtilloides.

TREES :

Mean taxa/plot = 2.2 ± 0.20 (S.E.) (*low*)

FREQUENT SPECIES : black spruce, (larch, balsam fir)

DOMINANT SPECIES : black spruce, (larch, red spruce)

SELECTIVE SPECIES : black spruce, larch

SHRUBS / SMALL TREES :

Mean taxa/plot = 2.3 ± 0.21 (S.E.) (*high*)   Mean total shrubs/plot = 9.5 ± 1.3 (S.E.) (*high*)

FREQUENT SPECIES : black spruce, *Viburnum cassinoides*, balsam fir, larch, *Nemopanthus mucronata* , (grey birch)

SELECTIVE SPECIES : black spruce, larch, *Nemopanthus mucronata, Viburnum cassinoides*

REGENERATION TREES :

Mean taxa/plot = 0.90 ± 0.20 (S.E.) (*low*)   Mean total plants/plot = 3.7 ± 1.1 (S.E.) (*med*)

FREQUENT SPECIES : black spruce, red maple, (white birch, balsam fir)

SELECTIVE SPECIES : black spruce

STAND & TREE PROPERTIES

Forest Type	*Woodland Size (km^2)*	*Stand Age*	*Stocking Class*
SS^8 SH^1	≤5 km^2 ; >10 km^2	M^6 I^3 U^1	3^5 4^3 2^2

% Biomass	*Tree Height (m)*	*Tree Age (yr)*	*Actual Density (%)*
S^{10}	11.9 *(low)*	54 *(med)*	61 *(low)*

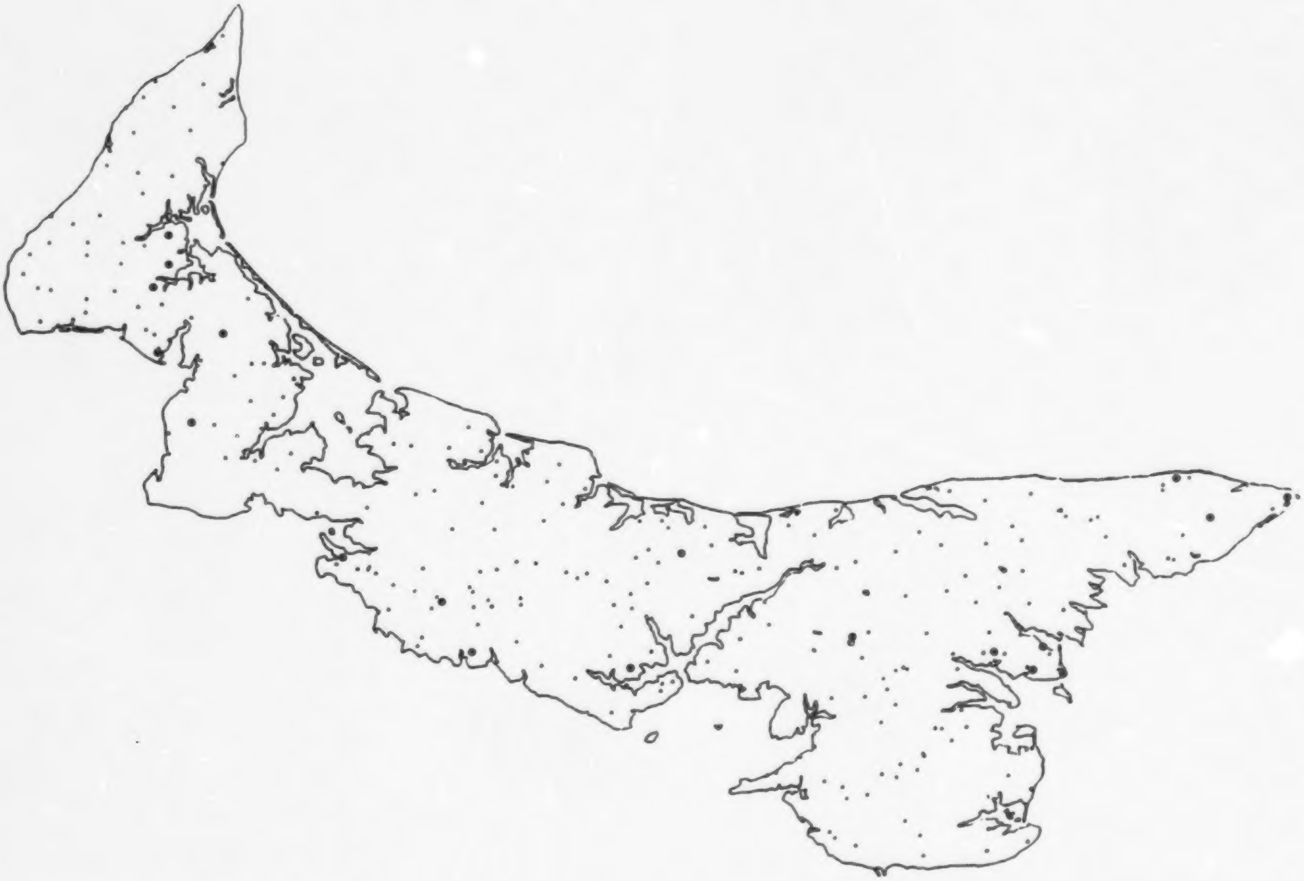
Stand Origin/History	*Status 1935*
PC^2 SW^2 N^2 (BOG^1)	FC^8 CL^2

ENVIRONMENT

Geographical Distribution	*Distance to Coast (km)*	*Distance to Road (m)*	*Elevation (m)*	*Slope*
W^4 E^3 C^3	3.6 *(low)*	496 *(med)*	19.1 *(low)*	L^9 S^1 (1.6°) *(low)*

Corn Heat Units	*Soil Series*	*Soil Texture*	*Soil Drainage*
2288 *(low)*	Mp^2 Or^2 Wn^1 Ch^1	O^3 SCL^1 SL^1 LS^1	P^7 I^2 W^1

pH	*% O M*	*N : C (%)*	*P (ppm)*	*Ca (ppm)*
3.9 *(low)*	58 *(high)*	3.3 *(low)*	170 *(med)*	980 *(low)*



GROUP 14

51 plots (4.5%)

GENERAL DESCRIPTION

A rather uncommon ground flora community-type occurring in larger woodland areas of varying drainage properties at lower elevations especially in parts of the western and eastern regions. The tree canopy is dominated by black spruce, with red spruce also of some significance. The ground flora is of moderate species-richness, with fifteen taxa selective for the group. Key site factors : level ground, soils of varying drainage from poor to good, bog characteristics, low base status, low nutrient content. Key stand factors : black spruce-dominated, low stocking rate, low tree height, medium tree age.

This group shows extensive overlap in species composition with Group 13, of which it appears to be a drier version. It also has a significant spatial association with Group 13. It is thus likely to fall within Erskine's lowland black spruce forest type, though he refers to black spruce as being only an occasional element of drier lowland sites.

GROUND FLORA :

Mean taxa/plot = 8.9 ± 0.38 (S.E.) (*med*)

Total taxa recorded = 52 Taxa with frequency > 5% = 28

FREQUENT SPECIES (12 species) :

Kalmia angustifolia, Pleurozium schreberi, Vaccinium angustifolium, Cornus canadensis, Pteridium aquilinum, Viburnum cassinoides, Dicranum polysetum, Ledum groenlandicum, Rhododendron canadense, Sphagnum spp., Vaccinium myrtilloides, Gaultheria procumbens

SELECTIVE SPECIES (15 species) :

Kalmia angustifolia, Ledum groenlandicum, Cladina rangiferina, Gaultheria procumbens, Vaccinium angustifolium, Cladina stellaris, Dicranum polysetum, Epigaea repens, Vaccinium myrtilloides, Pteridium aquilinum, Rhododendron canadense, Gaylussacia baccata, Ptilium crista-castrensis, Sphagnum spp., Pleurozium schreberi.

TREES :

Mean taxa/plot = 2.0 ± 0.16 (S.E.) (*low*)

FREQUENT SPECIES :	black spruce, (red spruce, balsam fir)
DOMINANT SPECIES :	black spruce, red spruce
SELECTIVE SPECIES :	black spruce, red spruce

SHRUBS / SMALL TREES :

Mean taxa/plot = 1.9 ± 0.17 (S.E.) (*med*) Mean total shrubs/plot = 8.9 ± 1.1 (S.E.) (*high*)

FREQUENT SPECIES :	black spruce, balsam fir, *Virburnum cassinoides*, red spruce, (red maple)
SELECTIVE SPECIES :	black spruce, red spruce, *Virburnum cassinoides*

REGENERATION TREES :

Mean taxa/plot = 1.1 ± 0.12 (S.E.) (*med*) Mean total plants/plot = 4.4 ± 0.79 (S.E.) (*med*)

FREQUENT SPECIES :	black spruce, red maple, (balsam fir, red spruce)
SELECTIVE SPECIES :	black spruce, red spruce

STAND & TREE PROPERTIES

Forest Type	*Woodland Size (km^2)*	*Stand Age*	*Stocking Class*
SS^7 SH^3	>10 km^2 *	M^5 I^3 U^2	3^5 4^4 2^2

% Biomass	*Tree Height (m)*	*Tree Age (yr)*	*Actual Density (%)*
S^9 H^1	12.6 *(low)*	57 *(med)*	48 *(low)*

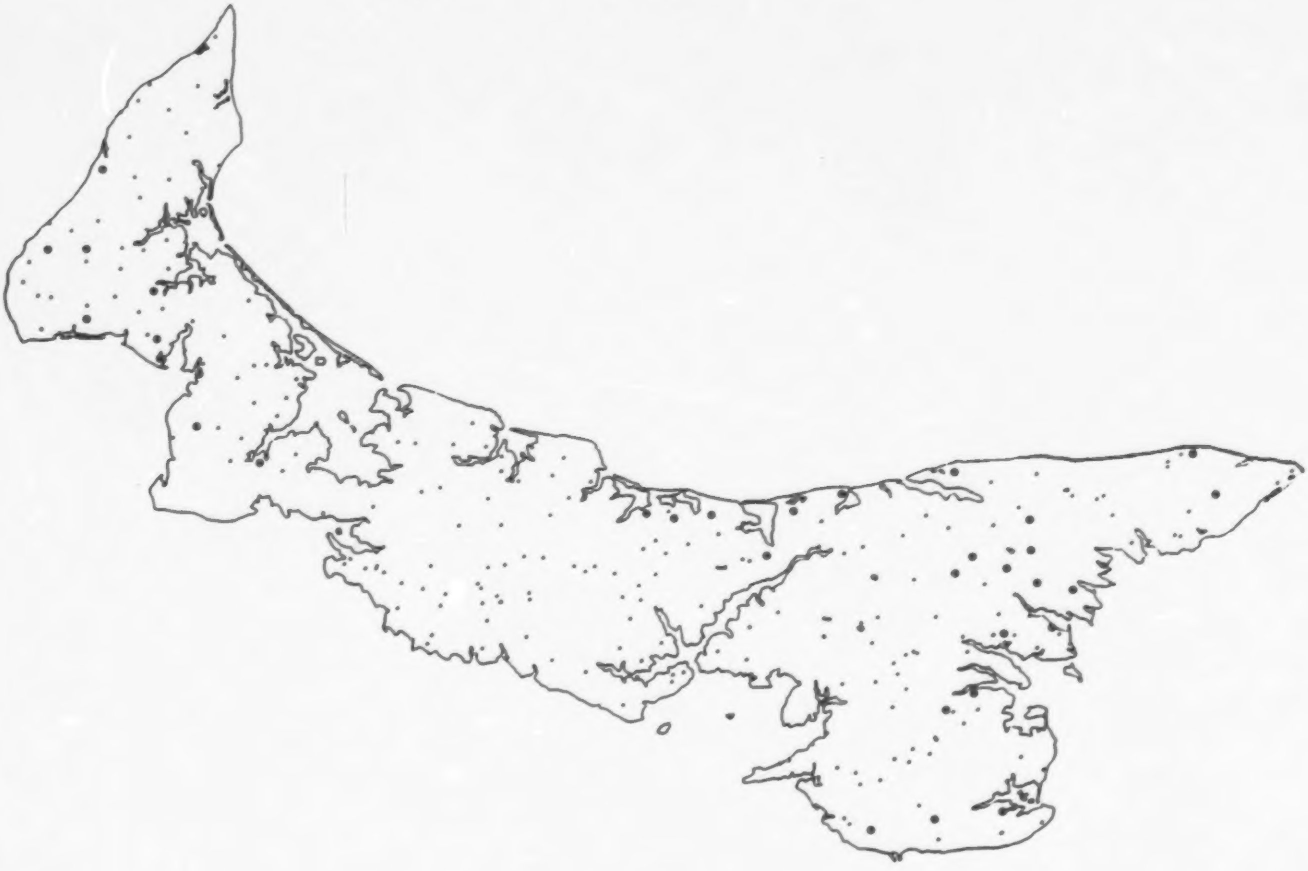
Stand Origin/History	*Status 1935*
N^4 PC^2 BOG^2	FC^8 CL^2

ENVIRONMENT

Geographical Distribution	*Distance to Coast (km)*	*Distance to Road (m)*	*Elevation (m)*	*Slope*
E^7 W^2 C^1	5.5 *(med)*	332 *(low)*	19.6 *(low)*	L^7 S^3 (1.5°) *(low)*

Corn Heat Units	*Soil Series*	*Soil Texture*	*Soil Drainage*
2284 *(low)*	Or^2 Cu^2	SCL^4 SL^2 LS^1	I^3 M^3 P^2 W^2

pH	*% O M*	*N : C (%)*	*P (ppm)*	*Ca (ppm)*
3.9 *(low)*	51 *(high)*	3.2 *(low)*	150 *(low)*	860 *(low)*



APPENDIX 2

THE FOREST VEGETATION-TYPES OF PRINCE EDWARD ISLAND : ANALYSIS AND DISCUSSION OF THE ELEVEN PRINCIPAL GROUND FLORA PLOT GROUPS GENERATED BY THE TWINSPAN ANALYSIS

The following section comprises an extensive analytical discussion of the floristic and environmental properties of the eleven principal ground flora plot groups generated at the fourth division level by the TWINSPAN classification. The data contained in the tables of Appendix 3 (of which the most significant elements are presented in summary form in Appendix 1) is here discussed in detail for each of the eleven TWINSPAN groups. Thus, Appendices 1 and 3 will need to be consulted when reading this section. (The tables referred to below which are prefixed by a number (e.g. Table 3-1) are found in the appendix of that number; those not prefixed are found in the main text.)

During the analysis it became apparent that Group 3 was more heterogeneous in its ground flora species composition than the other groups, and so a full comparison of all of the vegetation and environmental factors for its two sub-groups at the fifth TWINSPAN division level (Groups 3A and 3B) was carried out. Separate descriptions of these two sub-groups have been included in Appendix 1, while detailed data tables comparing the two sub-groups are contained in Appendix 5.

GROUP 3

[‘Wet rich deciduous woodland’]

GROUND FLORA.

Ground flora Group 3 (156 plots, 13.8% of all plots) is a species-rich plot type – a total of 161 taxa were recorded, with a mean of 13.7 species per plot (Tables 3-1, 3-2) – significantly higher than all other groups except Group 12. It is characterised by a long list of species which are absent from most other groups (except for the small Group 12, about which I will comment later). Among the more frequently occurring of these species are : *Rubus pubescens, Impatiens capensis, Onoclea sensibilis, Osmunda cinnamomea, Fragaria virginiana, Galium triflorum, Mitella nuda, Mnium* species, *Cornus stolonifera, Athyrium filix-femina,* and *Rhytiadelphus triquetrus.* Other characteristic species occurring at lower frequencies include *Aster puniceus, Gymnocarpium dryopteris, Aster umbellatus, Equisetum sylvaticum, Ribes lacustre, Galium palustre, Ptilidium pulcherrimum, Alnus rugosa, Circaea alpina, Eupatorium maculatum, Corylus cornuta, Dryopteris cristata, Equisetum arvense* and *Lycopus uniflora.* A number of more wide-ranging species also occur in this group – those of higher frequency include *Carex* species, *Dryopteris spinulosa, Viola pallens, Maianthemum canadense, Trientalis borealis, Sphagnum* species, *Aralia nudicaulis, Cornus canadensis* and *Pleurozium schreberi.* Most of these species, and especially the characteristic or ‘selective’ ones, were classified in Species Groups I and II in the TWINSPAN species classification (Figure 6, Table 1). They are recognizably plants of wetter and more nutrient-rich woodland (e.g. see Erskine 1960).

GROUPS 3A and 3B

The two sub-groups both show the same distinctively high level of species-richness which characterized the combined group – the mean numbers of species per plot for 3A was 14.2 and for 3B, 13.3. That it is best to treat them as *sub-groups* or variants of Group 3, rather than as full groups, is evident from their ground flora species make-up : they have in common most of the species that distinguish Group 3 from all of the other groups (see Table 5-1 – noting especially (among many species) *Rubus pubescens, Alnus rugosa, Fragaria virginiana, Galium triflorum, Ranunculus repens* and *Rhytidiadelphus triquetrus*). What differentiates the two (see the χ^2 column in Table 5-1) are the higher frequencies for particular species : 3B has higher levels of e.g. *Onoclea sensibilis, Mnium* spp., *Galium palustre, Impatiens capensis, Typha latifolia, Sphagnum spp., Eupatorium maculatum* and *Caltha palustris* – all species with a known preference for wetter habitats; while 3A has higher levels of two types of species – several (like those just listed) more or less exclusive to Group 3 (*Athyrium filix-femina, Epilobium angustifolium, Prunus virginiana* and *Corylus cornuta*), plus others which are also widespread in other TWINSPAN groups (*Trientalis borealis, Linnaea borealis, Clintonia borealis* and *Maianthemum canadense*).

TREE CANOPY

Ground flora Group 3 is associated with a variety of tree species – a total of 17 species was recorded with a mean of 3.4 species per variable-radius plot (Tables 3-3, 3-4). Over 60% of the stands were classified as hardwood-dominated (Table 3-12) (they were either HH or HS, i.e. ≥ 50% hardwoods), while almost 35% were softwood-dominated. Especially frequent in the variable-radius plots were balsam fir, red maple and white spruce. However, it is by comparing the biomass contribution of each tree species (Table 3-6), that we are able to more clearly distinquish their relative importance in this group : conifers and broadleaves each contributed almost exactly 50% to the biomass; the dominant species was red maple (25%) followed by white spruce (18%), and balsam fir (13.5%). Among the broadleaves, only trembling aspen and white birch made notable biomass contributions (7.2 and 5.6% respectively), but the small contributions of elm and white ash, and the presence of black ash and willow in this group, is ecologically significant. Among the conifers, the contribution of larch (7.3%), and especially cedar (7.1%), are also clear indicators of the nature of this plant community : this is essentially a wettish red maple-dominated woodland with lesser contributions being made by other moisturepreferring species such as white and black ash, elm, cedar and larch – it is the descendant of the pre-European 'red maple forest' proposed by Erskine (1960) (see Table 8).

Turning to the properties of the trees, the mean height of the measured trees was 14.5 m and their mean age was 60.4 years (Table 3-7) – the third oldest of all of the groups. The generally aged character of the trees on these sites is supported by the assessment of the stand ages (Table 3-12) : this group had among the lowest proportion of immature stands (19%) and (apart from the related Group 12) the highest proportion of overmature stands of all of the ground flora groups (14%). However, the majority of the stands were either uneven-aged (35%) or mature (30%).

The stocking rate of the stands in this group (Table 3-12) is significantly different from that of the stands as a whole, with a lower proportion in the highest stocking class (31%) – compared with 62% for all of the plots combined – and higher proportions (compared with the plots in general) in the other three classes – with notably high proportions in the two lower stocking classes. This observation is partially supported by the 'actual density' (Table 3-7) which was 69% – which falls in the middle of the range of the eleven ground flora groups.

SHRUBS and SMALL TREES – With nine species occurring as shrubs or small trees at a frequency of ≥ 10% (balsam fir, alder and red maple were especially frequent) (Table 3-8), this group had a notably high number of shrubs/small trees per 16 m^2 plot (Table 3-9). As was so for the ground flora, a large number of shrub species were significantly associated with the group – the more noteworthy are speckled alder, cedar, mountain maple, willow species, beaked hazel, Canada holly (*Ilex verticillata*), black ash and *Taxus canadensis*.

REGENERATION TREES – In comparison with the other groups this group had a low frequency and abundance of regenerating tree species (Tables 3-10, 3-11). Only two of the species of tree size occurring in the group were frequently recorded in the regeneration size class : red maple and balsam fir. However, neither the frequencies nor the stem densities (Table 3-11) for these two species were significantly different from that of the other ground flora groups. In fact, the only regeneration tree significantly associated with this particular ground flora group was white ash, which was recorded in only four plots.

GROUPS 3A and 3B

There are no great differences between the two sub-groups in their tree canopies : as they do in the combined group, hardwoods and conifers contribute equally to the woody biomass of both sub-groups (Table 5-2) – though red maple and black spruce make a slightly higher (but statistically significant) contribution to the 3B group, while white spruce is higher in 3A . There are no differences between them in most of the canopy properties of the surrounding stands : forest type, stocking class, and woodland size (Table 5-5), nor in their measured tree ages and 'actual densities' (Table 5-10). The only canopy properties that do differ are tree height and the age class of the surrounding stands : the measured trees for Group 3A were significantly taller – on average by 1.5 metres (Table 5-10), while Group 3B had a greater association with overmature stands (Table 5-5).

Turning to the shrub/small tree component, the only notable difference was the higher frequency of pin cherry, hazel (*Corylus cornuta*) and white ash for Group 3A (Table 5-3). Group 3A also had a significantly greater number of regeneration tree species per plot (Table 5-4), with the frequencies for both balsam fir and white spruce being significantly higher.

SITE CHARACTERS

This ground flora group shows a very distinctive geographical pattern (Appendix 1 : Group 3 map), being particularly associated with the western and eastern regions of the Island – significantly so with the western region (Table 3-12). Its few occurrences in the central region are mostly along the Bradshaw River valley at Bedeque. The plots in the western part of the island are fairly well distributed (except for an apparent sparseness around O'Leary), but those in the east are notably low in the area of the southeastern hills and in the north-east peninsula. The mean distance of plots from the coast (4.7 km) was on the low side (Table 3-21).

The mean elevation of the plots above sea level (19.5 m) is the second lowest of all of the ground flora groups and is significantly lower than five other groups (Table 3-21). Most of the plots (69%) are also on level ground (Table 3-13), and the group has a relatively low mean slope (1.7°) (Table 3-16). The low elevation of the sites and their short distance from the coast accounts for the moderately low level for corn heat units (2304) at these sites (Table 3-21).

Group 3 did not show any significant spatial association at the 240 sampling sites with any of the other ground flora groups (Table 3-19), and in fact it had the highest level of self-association of any of the groups : 49.4% of the associates of an average Group 3 plot were other plots of Group 3. [1]

Turning to management and historical factors (Table 3-12), the most notable feature of the stands in this group is that a higher proportion than for the plots as a whole was classified as 'swampy' (17%), and that there was far less evidence of past burning in this group than in the other groups (only 3.2% compared with 10.2% for all of the plots combined). Otherwise, there was evidence of considerable human activity in most of the plots – only for 26% was no factor recorded, and clear- or partial-cutting in the past was evident in 34% of the plots. On the ground, there was evidence that 18% of the plots were once 'old fields', while assessment of the 1935 aerial photo survey indicated that 14% of the plots were cleared land at that time. Combining these two types of data suggests that at least 27% of the plots were once cleared land. The mean distance of the plots from roads or buildings was 454 m (Table 3-21), while the group showed no association with any particular woodland size class (Table 3-20).

GROUPS 3A and 3B

The two sub-groups are indistinquishable in their geographical distribution (Appendix 1 : Group 3A and 3B maps; Table 5-5), in their spatial association with the other TWINSPAN groups (Table 5-11) (in fact both show their highest level of association with each other), and in their elevation, distance to the coast, and corn heat units (Table 5-9). Group 3B had a notably greater 'distance to the nearest road or building' (499 m compared with 400 m), which was just short of being statistically significant at the 5% level.

The two groups differed in their 'stand origin/history' (Table 5-5) : 3B shows a positive association with 'swampy' stands (27% were classed as such, compared with 4.2% of Group 3A plots), while 3A is significantly associated with the 'old field' category (31% of its plots were so, compared with 7% of 3B plots), and though the differences in their 1935 status were not significant, when the evidence from the aerial photos and the field survey are combined, 3A has a significantly higher association with formerly cleared land (39% of its plots were so, compared with 16.5% of Group 3B's). This greater degree of human intervention in the better drained 3A plots may also account for the higher biomass contribution of white spruce on these plots, as well as of white birch and trembling aspen – both early successional hardwood species. Conversely, the lower degree of human interference in the Group 3B plots may explain their positive association with the overmature stand age class.

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[1] The high level of self-association of the plots of this groups suggests that where such vegetation does occur it tends to extend evenly over a larger area than do other groups – though it should be noted that the lower levels of self-association for some of the other groups could simply mean (as will be evident later) that they are less valid than Group 3 as distinct vegetation-types – e.g. the dry hardwood flora groups – 5, 6 and 7 – if treated as a single combined group have an even higher level of self-association than Group 3. Despite this evidence suggesting that this vegetation-type may often extend over larger areas than other groups, I have found small pockets of what was clearly Group 3 vegetation occupying wet hollows a few metres across in the midst of other dryer vegetation-types.

SOIL PROPERTIES

Group 3 occurred on a wide range of soil textures (Table 3-13), plus a few plots (9.6%) occurred on organic materials. There is however clearly a positive association with fine-textured soils – 16% occurred on such soils, especially silty clays; and oddly, also with coarse-textured soils – 24% occurred on sands or loamy sands. Thus, medium-textured soils are under-represented in this group – only 3.2% of the plots were on loams compared with 25% for all of the plots combined. In terms of soil drainage (Table 3-13), 58% of the plots were either imperfectly or poorly drained, most (42%) being poorly drained, and in 28% of the plots a high water table was presenting problems for plant root development. Thus, only a minority of plots were well or moderately well drained – in fact only 18% of the plots were in the well-drained class. Despite the problems of a high water table in some of the plots, the average rooting depth (59 cm) was as high or higher than in most other groups, and the A horizon was thicker (30.6 cm) (Table 3-16).

The poor drainage of these sites is even more evident from the results of the soil series assessment (Tables 3-17, 3-18) : over 80% of the plots in this ground flora group occurred on imperfectly or poorly drained series, a significant positive association occurring with the poorly drained Rocky Point, Winsloe, Mossy Point and Baptist Point series and the imperfectly drained Malpeque series, and a significant negative association with the better drained series (i.e. Charlottetown, Alberry and Culloden).

Of the soil chemical properties (Table 3-14), the one that strikingly distinquishes this ground flora group from the other groups is the very high and statistically significant pH for both its H and B horizons : the H horizon had a mean pH of 5.4 – compared with 4.2 or less for all of the other groups except Group 12, while the pH of the B horizon was 6.2 – all other groups (again excluding Group 12) had a mean pH of 5.2 or less. This is clearly associated with the correspondingly high and statistically significant levels of calcium and magnesium in both the H and B horizons in this group.

The organic matter content of Group 3 (38%) – calculated from the total carbon in the H horizon (22%) – is in the middle range of the different ground flora groups – it is significantly higher than those groups which occurred entirely on mineral soils (e.g. Groups 6, 7 and 10), but less than those groups in which a high proportion of the soils consisted of organic matter (i.e. Groups 12 and 13). However, the nitrogen content of this organic matter is higher than for all of the other groups – this is evident from expressing the nitrogen content as a percentage of the soil carbon content (a value of 5.9% is obtained) – or, putting it the other way around, the C : N ratio (16.9) is the lowest of all of the groups. It is probably also the high organic matter content of the H horizon of this group which has contributed to its significantly higher sulphur content. However, a feature of the soils in this group that it is difficult to account for, is that it has the lowest phosphorus and potassium contents of all of the groups – significantly lower than many of the others. (It may be relevant here that of all of the macronutrients it was only phosphorus and potassium that showed a significant negative correlation with pH – see Appendix 6 : Table 6-1.) Turning to the micronutrients (Table 3-15), all of the levels appear to be at the higher end of the range, and two are significantly so : boron in the H horizon and manganese in the B horizon are significantly higher than in most of the other groups.

GROUPS 3A and 3B

Although the pH's of both the H and B soil horizons for the two sub-groups did not differ (Table 5-7), there were very great differences in many of their other soil properties – the key difference appearing to be in their soil drainage (Table 5-6) : Group 3B has a significantly higher association than 3A with poor drainage conditions – this is evident from all of the indicators of soil drainage, especially the field assessments of soil drainage class, and of water table as a root restriction factor, but also from the map assessment of the soil series. A factor contributing to these poorer drainage conditions for 3B would appear to be its higher association with level land – 80% of its plots were such, compared with 55% of Group3A's (Table 5-6).

The differences in other soil factors between the two groups may be the result of the difference in soil moisture levels : Group 3B had much higher levels of organic matter in both the H and B horizons (as indicated by the percentage carbon content) (Table 5-7) (which corroborates its significant association with the organic class in the soil textural analysis (Table 5-6)). For the H horizon there were also higher levels in 3B for most of the factors correlated with organic matter (see Appendix 6) : nitrogen, sulphur, calcium, magnesium, boron and zinc , and also with copper (Tables 5-7, 5-8). These differences did not occur in the B horizon, nor were there any differences in their phosphorus or potassium levels for either of the horizons.

CONCLUSIONS

This plant community-type is floristically and geographically distinctive occurring on level, wettish, comparatively base- and nitrogen-rich soils, with higher levels of most of the micro- and macronutrients (with the exception of phosphorus and potassium) than most of the other ground flora groups. The field visits of 1992 and 1994 confirmed the floristic and visual distinctiveness of this plant community-type in comparison with the others : its lush vegetation cover and large number of distinctive species was very evident – as was the wetter nature of such sites – even in summer. [2]

This ground flora group clearly corresponds to the lowland red maple forest of Erskine (1960) (see Table 8) – which he considers would have been the principal forest-type over much of the more poorly drained lowland areas in the period before European settlement. And Erskine's comment that "the herbaceous plants of the [lowland] red maple forest vary with the wetness of the site" is supported by the analysis of the two sub-groups of this vegetation-type – Group 3B is clearly a wetter variant of this forest type than 3A – this is evident from both its species make-up and from the assessments of soil moisture levels. The only other environmental difference between these two variants – the lower level of past forest clearance on 3B – may be a direct result of its higher soil moisture levels. However overall, the broad overlap in the ground flora composition between these two sub-groups, their close geographical and spatial association, and the limited differences in their tree canopies suggests that they are localized plant community variants within the lowland red-maple dominated forests of the Island, with the level of soil moisture determining which of the two is present. The species data collected (see the species lists of Table 5-1) adds considerably to the few species that Erskine (1960) lists as distinquishing the wetter and dryer ground flora community variants of this forest type.

It is now probably impossible to reconstruct the appearance of the unexploited form of this lowland red maple forest on the Island – though there may be undisturbed sites on the adjacent mainland which would enable us to appreciate its original appearance. The trees in today's forest are likely to be smaller and younger than their undisturbed ancestors (though Stewart's (1806) comment must be borne in mind : "red maple ... is generally found growing in swamps and is small and of no value" – presumably in comparison with the tolerant hardwood species on dryer soils). We also cannot be certain that the tree species make-up at any site at the present time would correspond to that of the past – it is probable that other species, now generally of minor importance (e.g. elm, white ash, black ash, and cedar) may have been of greater significance, at least locally, and they may well have achieved dominance in some areas; however, I think it is less likely that the present-day ground flora differs greatly in its appearance and species make-up from its pre-European equivalent, but we have no past information to be certain of this.

Is it possible to obtain a more accurate picture (than that contained in the Group 3 map in Appendix 1) of the present distribution of this wet lowland forest-type ? Apart from resorting to laborious field-work, there are two different starting points for such an excercise – one is a computer-generated map (Figure 7 - from Glen 1993) showing all of the forest stands on the island in which red maple comprises at least 5% of the tree canopy (as determined from analysis of the 1990 false colour infra-red aerial photo survey). However, there are major problems here : red maple has always been a significant component (in some places probably dominant (Table

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[2] Also apparent was the small-scale level of heterogeneity that can occur at such sites : at some sites certain species were found in the wetter hollows (e.g. *Impatiens capensis*, *Ranunculus repens*, *Carex* spp., and *Mnium* spp.), while only 40-50 centimetres away, on slightly higher 'islands', sometimes around tree roots, different species predominated (e.g. *Rubus pubescens*, *Mitella nuda*, *Dryopteris spinulosa* and *Sphagnum* spp.).

10)) of the *upland* deciduous forest (Erskine 1960), and in addition, in this upland habitat it has greatly expanded beyond its pre-European distribution as a result of its more ready response to (and/or recovery from) disturbance than the other tolerant hardwood species – the 1991 Inventory indicates that it is now the dominant tree component of the upland deciduous forest. As well, it occurs at significant levels in most other forest types (e.g. see Tables 3-3 and 3-5). Thus the 1990 red maple map cannot be directly used to indicate the distribution of the wet deciduous forest (in fact the 1990 distribution of red maple is probably more representative of the *total* forest cover of the Island, than of any particular forest-type !). But if we were to subtract those red maple stands in which sugar maple was also a component (e.g. by using the map of sugar maple stands in Figure 7), plus at the same time raising our mapping threshold for red maple from 5% to 20 or 30% (to eliminate the many stands where this ubiquitous species occurs at lower levels), then we might get a reasonable picture of the present distribution of the lowland red maple forest on the island. The potential for such mapping is certainly there, given that the whole data set is stored by the Forestry Branch and requires only computer manipulation.

The second starting point in such a mapping exercise are the soil series maps (at a scale of 1 :10,000) produced by the Soil Survey of Prince Edward Island (MacDougall *et al.* 1988). Although we must bear in mind that the map units are not 100% pure for the particular series named, and that subjective decisions must have been involved in allocating boundaries – all the same, if there was a close correlation between a ground flora group and a specific soil series, then the spatial distribution of that series might be taken to show the distribution of a vegetation-type. We have seen that Group 3 was significantly associated with poorly and imperfectly drained soil series (over 80% of its plots occurred on such soils) – however, for any particular soil series this relationship was not exclusive (e.g. Group 3 was especially associated with the Rocky Point series – 24 of the 34 Rocky Point soils in the TWINSPAN analysis were classified in Group 3 (a highly significant association statistically), but even so, this means that ten Rocky Point soils fell in other TWINSPAN groups) – so it seems that at present the soil series maps are not likely to lead to anything precise enough to enable us to map Group 3 vegetation. However, it may be that in future soil surveys, attention might also be paid to the ground vegetation, enabling the more accurate characterization of the vegetation associated with each series (for example, its placing in a particular TWINSPAN group) and the production of accurate vegetation maps.

Given the difficulties in producing an accurate map of the present-day distribution of the wet deciduous woodland on the Island, it is obviously much more difficult to do so for its pre-European-settlement equivalent. However, it is worth noting (as Erskine also observes) that it is likely that a higher proportion of the original area of the Island carrying lowland woodland is still forested (in comparison with forests on the dryer soils) since such sites, being wetter, would be less likely to be cleared for agriculture.

GROUPS 5, 6 and 7

['Upland' hardwood forest']

GROUND FLORA.

In the TWINSPAN classification (Figure 2) an initial large group of 430 plots (38.2% of the total), comprising what appears to be the ground flora of the dry shade-tolerant hardwoods of the Island, was separated at the second division level from the ground flora of the wet hardwoods (i.e. Group 3). This large group was further subdivided into three separate plot types which, although they overlap to a degree in species make-up, appear to have some ecological validity in terms of their tree composition and environmental factors. Thus, these three tolerant hardwood ground flora plot types will be partially distinguished in the discussion – their ground flora will be described separately, but their tree canopies and environmental factors will then be discussed comparatively as variants of a single large group.

GROUP 5. – This plot type is less common than the other two related groups (77 plots, 6.8% of all plots). It is a relatively species-poor group (Tables 3-1, 3-2) – 63 taxa were recorded in total, with a mean of only 5.6 species per plot, and is characterised by very high frequencies of two species – *Dryopteris spinulosa*

(92%) and *Taxus canadensis* (64%). Also characteristic of this group, though occurring at low frequencies are *Acer spicatum* and *Oxalis montana*. Present at high frequencies are a number of more ubiquitous species : *Aralia nudicaulis, Maianthemum canadense, Trientalis borealis, Clintonia borealis,* and *Cornus canadensis.*

GROUP 6. – This plot type, with 196 plots (17.4%), is the largest of all the ground flora groups. It is more species-rich than Group 5 – a total of 161 taxa were recorded with a mean of 7.7 species per plot (Table 3-1). Ubiquitous, less discriminating species predominate : *Maianthemum canadense, Trientalis borealis, Aralia nudicaulis, Dryopteris spinulosa, Clintonia borealis, Viola pallens* and *Cornus canadensis* – though five of these are 'selective' for this group (i.e. they have a significantly higher frequency value in this group than in all of the plots taken together.) The group also appears to be an important repository of some more discriminating hardwood ground flora species: *Trillium undulatum* (which is also an important component of Group 7), *Aster acuminatus, Viola incognita*, and at less than 10% frequency : *Cornus alternifolia, Smilacina racemosa, Sambucus pubens,* and *Streptopus roseus.* Also selective for the group is a species which is more characteristic of clearings (e.g. Hinds 1986) : *Rubus canadensis.*

GROUP 7. – This group contained 155 plots (13.8% of the total), and with a mean of 6.9 species per plot (Table 3-1), it is intermediate in species number between Groups 5 and 6. It is characterised by notably high frequencies of *Dennstaedtia punctilobula* and *Lycopodium obscurum*, and also has the highest levels of the following selective species : *Trillium undulatum, Medeola virginiana, Lycopodium annotinum*, and (for species of < 10% frequency) : *Lycopodium lucidulum, Monotropa uniflora* and *Smilacina racemosa.* Like Groups 6 and 7 it also has high levels of *Maianthemum canadense, Trientalis borealis, Aralia nudicaulis* and *Dryopteris spinulosa.*

TREE CANOPY

The stands in which all three of these ground flora groups occurred were primarily composed of hardwoods (Table 3-12), with Group 5 being the most 'pure' – 77% of its stands were in the HH forest type class (i.e. containing > 75% hardwood species) and none were in the SS class. The other two groups, especially Group 6, show a greater intrusion of softwoods, although the great majority of their stands were still dominated by hardwoods – the combined HH and HS classes (i.e. > 50% hardwoods) were 80 and 92% for Groups 6 and 7 respectively.

Turning to the quantitative tree data, the mean number of tree species per plot (Table 3-3) was exactly the same for each of the three groups (3.6) – the total number of tree species recorded being 16, 23 and 17 respectively. In all three groups there were high frequencies of red maple and balsam fir, followed by sugar maple, white birch, white spruce, yellow birch and beech. Sugar maple, red maple and yellow birch were selective (i.e. signficantly associated) for all three groups, while beech was selective for only Groups 6 and 7. Striped maple and hemlock, although occurring at low frequency levels, were selective for Group 5, while white birch was so for Groups 6 and 7.

Although these differences between the groups in the tree frequencies are informative, it is more useful to examine the contribution of each of the species to the total tree biomass of the plots (Table 3-5) : broad-leaved species predominate over conifers in all three TWINSPAN groups – 77, 63 and 75% respectively of their total biomass was contributed by broad-leaves. The most important contributor in each of the three groups is red maple with a 40, 28 and 38% contribution, followed by (among the broad-leaves) sugar maple with 18, 7 and 10%. When added together, the three tolerant hardwood species (sugar maple, yellow birch and beech) contributed 31, 15 and 19% to each of the three groups respectively – sugar maple and yellow birch making their greatest contribution to Group 5, while beech (although much lower at 5.2%) contributed its greatest to Group 7. Other broad-leaf species characteristic of the northern hardwood forest make small contributions to the biomass of the three groups : striped maple, white ash, elm, mountain maple and red oak – as well as the shade-tolerant conifer, hemlock.

Turning to the softwood species and their broad-leaved associates, balsam fir is the most significant, contributing about 19% to the tree biomass of each of the three groups, followed by white spruce, which contributes a much smaller amount – the greatest (13%) being to Group 6. Other conifers are of little significance, but two of their broad-leaved associates (white birch and trembling aspen) contribute small amounts, especially to Groups 6 and 7.

In comparing the measured tree properties (Table 3-7), some notable differences between the three groups become evident. Group 5 contains the oldest and tallest trees, as well as those with the greatest 'actual density': the mean height of the measured trees in Group 5 was almost a metre greater than the other two groups (16.3 m compared with 15.6 and 15.2 respectively), and the trees were older by ten years on average (67 years compared with 57 years for the other two groups). Both of these differences were significant statistically. The 'actual density' for Group 5 (90.6%) was just slightly greater than for Group 7, but considerably higher than the value for Group 6 (81.9%).

The observations made on the stands surrounding the plots (Table 3-12) are in agreement with the above points : Group 5 contained the lowest proportion of immature and regeneration stands of the three groups – 23% of stands compared with 28 and 37% for Groups 6 and 7, and its stocking rate was also the greatest : 93.5% of its stands were in the highest stocking class, the equivalent values for Groups 6 and 7 being 70 and 81% respectively.

SHRUBS and SMALL TREES – The overall frequency of plants of shrub size in these three groups (Table 3-8) was at a moderate level in comparison with the other TWINSPAN groups, with Group 6 having a somewhat higher total shrub frequency than Groups 5 and 7. In species make-up, their shrub components were quite similar to their tree canopies – frequent in all three groups are balsam fir, red maple and sugar maple. Group 5 is especially characterised by mountain maple, while striped maple, sugar maple and yellow birch also have a significant association with this group. Beech is notably higher in Group 7 – as it was also for trees – while Group 6 has a larger range of both frequent and selective species, including species not characteristic of tolerant hardwood forest – such as white birch, white spruce and pin cherry.

REGENERATION TREES – As was so for most of the other TWINSPAN groups, the two most frequent regenerating tree species in this group were balsam fir and red maple (Table 3-10) – with the frequencies of balsam fir in Groups 6 and 7 being significantly higher than in all of the plots combined. There were also comparatively high and significant frequencies for sugar maple and striped maple in all three groups, while in Group 6, yellow birch, and in Group 7, beech, although at lower frequencies, were significant.

SITE CHARACTERS

In terms of geographical distribution all three groups show a broadly similar spatial pattern, with a significantly positive association with the central region of the Island (Table 3-12). Overall on the Island there is a concentration of points in specific areas (Appendix 1 : Groups 5, 6, 7 maps) : in the central hill-lands, the southeastern hills, the north-east peninsula, and, in west Prince County, in the areas around O'Leary and near Tyne Valley – all of these are known to be areas containing remnants of the Island's hardwood forests (Erskine 1960, Glen 1993). The most concentrated in area of the three groups is Group 5, while Group 6 is the most dispersed, with a wider scatter of points in the far west and in the central region of the province. Group 7 appears to have fewer occurrences in the north-east peninsula. These observations on distribution are in agreement with the mean distances of the three groups from the coast (Table 3-21) – Groups 5 and 7 had the highest mean distances of all of the ground flora groups (7.8 and 7.6 km respectively) – notably higher (and for Group 7 significantly so) than for Group 6 (5.7 km).

Groups 5 and 7 also had the highest mean elevation above sea level of all of the groups (47.5 and 50.4 m) – notably higher than the 36.9 m of Group 6 (Table 3-21). In slope and aspect (Table 3-13), all three groups exhibit a negative association with level ground : only 20% of the plots in Groups 5 and 7, and 27% in Group 6 were on level ground – compared with 37% of all the plots analysed. The mean slope for all of the plots in these three groups (Table 3-16) was the highest of all eleven TWINSPAN groups – 2.1°, 2.5° and 2.4° respectively. In terms of the aspect of the sloping plots (Table 3-13), Group 5 had a higher proportion of south-facing slopes (19.5%) than would be expected due to chance, and Group 7 more north-facing and south-east-facing slopes. Their higher elevations and greater distances from the coast would account for the notably high mean corn unit values for Groups 5 and 7 (2323 and 2325), though Group 6's value (2321) was also high (Table 3-21).

There was a fairly high level of spatial association beween the three groups at the 240 sites, and they were correspondingly either indifferent to, or negatively associated with, all of the other ground flora groups (Table 3-19). Each of the groups showed the highest level of association with other plots of the same group, and was associated with the other two groups as follows : Group 5 was significantly associated with 6 but not with 7, Group 6 was significantly associated with both 5 and 7, while Group 7 was significantly associated only with Group 6.

Turning to management and historical factors (Table 3-12), these three groups contain a high proportion of plots where no factor was recorded (34, 29 and 36% – the greater values being for Groups 5 and 7) – which suggests less recent disturbance of these plots. However, other plots in these groups did show signs of disturbance : for all three groups there was evidence of thinning or partial cutting in about a third of the plots, and 10% of the plots in Group 6 had been clear-cut in past years – significantly higher than the amount of clear-cutting in all of the 1127 plots combined (5.7%). In Groups 5 and 7 there was evidence of past burning in about a fifth of the plots – also higher than for all of the plots in general. [3] Of the three groups, Group 6 had the highest proportion of plots which contained evidence of having once been cleared land : 16% were recorded as 'old field' in the Inventory, compared with 6.5% in Group 5, and only 1.9% in Group 7; and the 1935 aerial survey indicates that Group 6 also had the largest proportion of cleared land plots (14%) compared with 10% for Groups 7 and only 4% for Group 5. Combining these two types of data suggests that at least 25% of the Group 6 plots were once cleared land compared with only 10 to 12% in the other two groups.

In terms of woodland size (Table 3-20) notable differences emerge between the three groups : Groups 6 and 7 were more frequently found in smaller woodlots – they were positively associated with woodland areas of under 5 km^2 and negatively associated with woodlands of greater than 10 km^2. By contrast Group 5 was most frequently and significantly associated with wooded areas of 5-10 km^2. This agrees with the finding (Table 3-21) that Group 5 plots had the greatest mean distance of all of the ground flora groups from roads or buildings (597 m) – considerably higher than the values for Groups 6 and 7 (491 and 477 m respectively).

SOIL PROPERTIES

In terms of soil texture (Table 3-13), Group 5 has a notably high association with loamy soils – 43% of its plots had such a soil texture – compared with only 25% of all of the plots in the analysis. For all three groups there appears to be a negative association with the fine textured clay and silty clay soils, and for Groups 5 and 7, with the coarse textured loamy sands and sands – though overall the proportion of such fine and coarse soils recorded in the Inventory was low – only 14.2% of plots.

The vast majority of the plots in all three groups occurred on well-drained soils (83 to 94%), with Group 7 showing the most distinct association with this drainage class (Table 3-13). Group 5 had a few plots (5.2%) that were imperfectly drained, but in not one of the plots in any of the three groups was root development restricted by a high water table. The average rooting depth in the three groups (Table 3-16) was about the same (54 to 58 cm), as was the thickness of the upper mineral A horizon (18.4 to 19.6 cm) which, incidentally, is less than that of all of the other groups except Group 11.

The evidence from the soil series assessment (Tables 3-17, 3-18) agrees very well with the above field observations : 80, 86 and 97% of the plots in the three groups were on soil series with good drainage (i.e. rapidly, well or moderately well drained) – with Group 7 having the highest percentage. More specifically, all three groups were significantly associated with the Charlottetown series, with Group 5 being also significantly associated with the Alberry series.

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[3] See footnote 3, p. 17

Turning to the soil chemical properties (Table 3-14), despite the fact that there was little difference in the pH values for the H horizon of the three groups (4.3, 4.3, 4.2), the percentage carbon in the H horizon, indicative of organic matter content, was much higher for Group 5 (33.6% organic matter) than for Groups 6 and 7 (23.3 and 20.5% respectively) – with the difference between Groups 5 and 7 being statistically significant. The nitrogen content of the organic matter (expressed as % N : C) was similar for the three groups, ranging between 5.0 to 5.4% (i.e. C : N ratios of from 18.5 to 20.0), but was higher than for all of the other groups except Group 3. The higher organic matter content for Group 5 is probably the reason why all but one of the other five macronutrients were also higher in its H horizon compared with Groups 6 and 7 – phosphorus, sulphur, potassium and calcium. The exception was magnesium where the levels in Group 6 were slightly higher. None of these differences were significant in the Scheffe test but the trend appears too consistent to be spurious. Groups 6 and 7 do exhibit some differences in their macronutrient levels, but there is no consistent pattern to the differences. The analysis of the same macronutrients for the B horizon reveals much lower values for all of the macronutrients compared with the humus horizon, but the differences in the values for the three groups are less, and there are no consistent trends. It thus appears to be the H horizon which contains the key to the differences in soil properties among the groups. There is little to comment on in the micronutrient analyses (Table 3-15) except that Group 7 had the highest manganese level of all eleven groups as well as the lowest zinc level.

CONCLUSIONS

Groups 5, 6 and 7 together contain the ground flora of the tolerant hardwoods of the Island, but the three groups appear to be legitimate variants within this larger group.

Group 5 comprises the purest of the tolerant hardwood types : of the three groups, it has the largest proportion of tree biomass contributed by broad-leaves (77%), the largest proportion contributed by climax hardwood species (sugar maple, red maple, beech, yellow birch) (72%), and excluding red maple, the largest proportion contributed by the three tolerant hardwood species themselves (31%). Further narrowing, it also has the largest contributions by sugar maple and yellow birch. Conversely, it thus has the lowest contribution to biomass from conifers (22.6%) – but 18.8% was contributed by the shade-tolerant conifer, balsam fir. Thus, white spruce contributed only 3.1% and successional broad-leaves (white birch and trembling aspen) only 6.8%. Further confirming this predominance of climax hardwood species is the fact that the forest stands in which Group 5 plots were located had the highest proportion of sites (77%) classified as HH (i.e. >75% hardwoods), and 91% were either HH or HS (i.e. > 50% hardwood).

Within this largely pure hardwood group, the measured trees were the tallest and the oldest of the three hardwood groups, and the sites on which they occurred had the lowest proportion of regeneration and immature stands. The trees were also the most densely stocked of the three groups with the highest 'actual density' and the greatest proportion of stands in the highest stocking class (Class 4).

The soils of this group tend to be richer in nutrients – there is a high proportion of loams, and the organic matter content and total macronutrient levels of the H horizon are the highest of the three groups. In general, they are well-drained, though perhaps not so well as the other two groups, as there is a higher proportion of imperfectly drained soils in this group.

This Group presents some slight evidence of being less disturbed than Group 6, though not less so than Group 7 : it has a slightly higher proportion of plots than Group 6 in which no disturbance or historical factors were recorded. It also has a smaller proportion of clear-cut plots, though at the same time, about a third of its plots showed evidence of thinning or partial-cutting. And of the three groups, it shows the smallest proportion of plots that were cleared land in 1935, though when the Inventory field evidence is added, it has the same number of old field plots as Group 7. In agreement with this apparent lower level of past disturbance is the fact that Group 5 plots were associated with wooded areas larger than Groups 6 and 7 and were at a greater distance from roads or buildings.

Geographically, the concentration of this group in the areas of the Island where the larger remnants of hardwood forest remain, rather than in areas where small woodlots predominate, also supports the theory of less frequent past disturbance.

I propose that we thus may have here the ground flora group that approximates most closely to that of the undisturbed tolerant hardwood forests that once covered extensive areas of the Island. Or, putting it another way : given that there are no areas of forest on the Island that are not affected by three centuries of continual human exploitation (including Group 5, as is evident from the data on origin and historical factors) – of the three hardwood ground flora groups, human influence is likely to have been less in Group 5 than in Groups 6 and 7. A lower level of human disturbance in Group 5 is likely to account for the fact that its trees are the tallest and oldest (as well as the densest) of the three groups. However, we still cannot rule out the influence of innate site factors on the ground flora of this group – the high incidence of loams is a pointer. And it may be such innate factors, rather than the lower level of human disturbance that is responsible for the higher macronutrient levels.

One of the ground flora species selective for Group 5 deserves special comment : *Taxus canadensis* (Canada yew or ground hemlock) had a frequency of 64% in the plots of this group – its highest frequency for any group (Table 3-1). It is obvious to any field observer that *Taxus* can form a dense ground cover which can act to exclude other plants (this was evident to me during my 1994 field visits and has been noted by Roland and Smith (1969)). [4] The possibility thus arises that ground flora Group 5 may simply consist of those 4 m^2 plots in hardwood forest that happened to fall in a dense clump of *Taxus* and that it is the *Taxus* which accounts for the species-poorness of this group compared with the other hardwood groups (it had a mean of 5.6 species per plot – compared with 7.7 and 6.9 for Groups 6 and 7). Though it is quite likely that *Taxus* has had an influence on the species make-up of some of the plots in which it occurs, I think that the many notable and significant differences (just summarized) which have been found to occur between Group 5 and the other two hardwood groups – in factors which could not possibly be affected by a high cover of *Taxus* (in tree canopy, geographical, management and soil factors) is strong evidence that we do have in Group 5 a ground flora group which is distinctive on a scale larger than due to the presence of one species. And we must remember that in 36% of the plots of this group no *Taxus* was present, yet their ground flora composition was similar enough to the plots with *Taxus* as to cause them to be classified in the same group.

There is an historical record which lends further support to the view that hardwood ground flora communities dominated by *Taxus* are a distinctive community-type : Stewart (1806), in describing the suitability of different types of forested land for clearance, advised that the best soils for agriculture were to be found under mixed hardwood forest where the surface was covered with the 'dwarf yew' – "always an indication of good land". He considered the soils under hardwood where there was no yew to be inferior to that where yew was present. The implication is that even in the undisturbed pre-European forest there were ground flora communities distinquishable on the presence and absence of*Taxus* whose soil properties differed on a level of practical importance. We might thus surmise that ground flora Group 5 is the modern descendant of Stewart's 'better hardwood lands' – its high and statistically significant association with loam soils certainly points in this direction. Since most of Stewart's better hardwoods were undoubtedly cleared in the eighteenth and early nineteenth century and have been under farmland ever since – we might ask why the sites now occupied by Group 5 plots were not cleared. This takes us into the realm of historical factors – all I can suggest is that their greater distance from roads and waterways may have been a factor.

By contrast with Group 5, Groups 6 and 7 appear to represent more human-disturbed variants of the Island's hardwood ground flora, with Group 6 appearing to be more disturbed than Group 7. The evidence for this is in the tree and shrub data : Group 6 has a greater intrusion of conifers, as well as early successional broadleaved species than does Group 7 – conifers contribute 37% of the total biomass in Group 6, with white spruce making up 13.4% and white birch and trembling aspen contributing an additional 15%. The equivalent values for Group 7 are less than these, but are higher than for Group 5. The classification of the sites on the basis of their forest type also supports this observation : 19% of the stands in Group 6 were either SH or SS (i.e. >50% softwoods) compared with only 6.5% for Group 7. Conversely, Group 6 has the lowest contribution by hardwoods to tree biomass (63%), the lowest contribution of the climax hardwood tree species (red maple, sugar maple, yellow birch, beech) (43%), and the lowest contribution of the three tolerant hardwoods themselves (15.2%). Also, only 50.5% of the stands in which the plots occurred were classified as HH – the lowest value for all three groups. With respect to all of these values, Group 7 is intermediate between Groups 5 and 6. However, for other tree measures there is generally an overlap between Groups 6 and 7, moreso than there is with Group 5 : e.g. Groups 6 and 7 have similar tree heights and ages.

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[4] Not only is *Taxus* taller and denser than many other ground plants, it also tends to catch and hold leaf litter – which causes additional shading and covering of any seedlings and small plants that have happened to establish beneath it.

My field visits in 1992 and 1994 indicate to me that despite the differences between Group 5 and the other two groups noted above, it is not always easy to distinquish between all three groups on the ground – especially between Groups 6 and 7. The fact that they can often occur within a hundred metres or so of each other (as indicated by their high level of spatial association) and the apparent importance of disturbance as the distinguishing factor between Group 5 and the other two groups – a factor that can change over a short period of time – means that at a general level, especially for the purpose of mapping, even if we consider them as real variants of one vegetation-type, it is more practical to treat them in combination.

The 1990 distribution map for sugar maple (Figure 7) (showing the stands in which it contributed at least 5% of the canopy) is likely to be our best indicator of the present spatial distribution of these three combined hardwood ground flora groups. This map shows a good correspondence with the Appendix 1 maps for the groups – showing the same predominance of this vegetation-type throughout most of the whole central region – either as scattered small patches in woodlots, or as a large block in the central hill-lands – as well as the distinctive geographical clusters elsewhere (in the west, around O'Leary and Alberton, and in a large area between Wellington and Tyne Valley; and in the east, in the south-eastern uplands, the north-east peninsula and in smaller scattered areas south of St Peters Bay.)

The hardwood forests now present in all of these areas, although likely to be the direct uninterrupted (albeit continually disturbed) descendant of the pre-European forest on such sites, will probably bear little resemblance to their primeval ancestor with respect to tree size and species composition. To appreciate the appearance of the original forest one has to go to present-day less recently disturbed sites such as the Townshend Woodlot (Taschereau 1974, Anon. 1982). To reconstruct the map distribution of this forest type before the effects of European settlement, we would probably need to add to our sugar maple stand map (Figure 7) all of the presently cleared farmland in the above areas, especially that underlain by well and moderately-well drained soils – notably the Charlottetown and Alberry series – with which the groups had significant positive associations. It is also likely that where such soil series are now covered with other ground flora types (e.g. some 30 to 52% of the conifer-dominated groups (8, 9 and 10) are on Charlottetown or Alberry soils) they too may once have been covered by hardwoods.

There was undoubtedly spatial variation in the composition of the pre-European hardwood forest on the Island before clearance and exploitation began : a few inhabitants and visitors to the Island in the late eighteenth /early nineteenth century (e.g. Curtis (1775), Stewart (1806) and Johnstone (1822)) have left comments indicating that the tree composition of the hardwood forest across the Island was far from uniform – and if this were so for the tree canopy it might also have been so for the ground flora. But more than two centuries of clearance, and the selective removal of particular tree species – either by human activity or disease (e.g. beech) – probably now makes it impossible for us ever to know what these variations were, let alone to attempt to map them.

GROUPS 8 and 9

['Disturbed conifer-dominated forest']

With Groups 8 and 9 we come to the first of the ground flora groups which fell to the right side in the first division of the TWINSPAN analysis (Figure 2) – the side largely comprising the conifer-dominated plots. At the third division level, Groups 8 and 9 comprised a single large group of 283 plots (25.1% of all plots). This large group was then divided into two groups : Group 8, comprising 165 plots, and Group 9, 118. However, as will become apparent, the differences between them are not very great, and they are best considered as variants of a single vegetation-type.

GROUND FLORA

Groups 8 and 9 had means of 9.8 and 9.5 ground flora species per 4 m^2 plot respectively (Table 3-1) – significantly greater than the values of many of the other groups – only Groups 3 and 12 had higher values. It is evident that these two groups have many ground flora species in common, and also at more or less the same frequency levels – *Maianthemum canadense, Trientalis borealis, Cornus canadensis, Viburnum cassinoides, Pleurozium schreberi, Coptis groenlandica* and *Linnaea borealis* are the more frequent of these. The main difference between them is in the frequencies of some of the other species : e.g. *Clintonia borealis, Dicranum scoparium* and *Aralia nudicaulis* occur at higher frequencies and are selective for Group 8, while *Pteridium aquilinum, Vaccinium angustifolium, Vaccinium myrtilloides, Kalmia angustifolia* and *Polytrichum commune* are higher and selective for Group 9. I do not think however, that these differences are sufficient to warrant the recognition of Groups 8 and 9 as two distinct ground flora groups. Rather, together they appear to exhibit a continuum of slight differences, and their close overlap in species composition makes it difficult to distinquish them in the field. They will thus be discussed as a single group with some comment on the more important differences occurring between them.

As a single group, they are clearly a repository of many of the more ubiquitous ground flora species of Island woodlands. In the order of their overall frequency in the combined group, the following are the more common species : *Maianthemum canadense, Cornus canadensis, Pleurozium schreberi, Trientalis borealis, Pteridium aquilinum, Aralia nudicaulis, Dicranum scoparium, Clintonia borealis, Polytrichum commune* and *Vaccinium angustifolium*. Other species more frequent in other groups also occur, but the only taxa which generally distinguish the combined group from the other ground flora groups are *Pteridium aquilinum* (joint frequency = 41.3%), *Linnaea borealis* (28.6%), *Coptis groenlandica* (19.1%) and *Amelanchier* spp. (15.9%) – though *Pteridium aquilinum, Coptis groenlandica* and *Amelanchier* spp. do have similar frequencies in a few other groups.

TREE CANOPY

The mean number of tree species recorded per plot was 3.4 for Group 8 and 3.2 for Group 9 (Table 3-3). Looking at the forest type of the stands (Table 3-12), Group 9 contained a higher proportion of softwood-dominated stands (SH and SS, i.e. > 50% softwoods) than did Group 8 – 58% compared with 40%. Despite the minority of Group 8 stands classed as softwood-dominated, in terms of biomass (Table 3-5), conifers did in fact predominate in both groups, contributing 73% of the total biomass in Group 9 and 59% in Group 8. Balsam fir was the most frequent and dominant species (as regards biomass contribution) in both groups, while the higher conifer contribution in Group 9 is largely due to the three spruce species (white, black and red – in that order), all of which make a greater contribution to the total biomass in Group 9 (the combined spruce value was 43%) than in Group 8 (27%). Three species largely account for the broad-leaved contribution to biomass – red maple, white birch, and trembling aspen – with red maple making the greatest contribution.

The greater ascendancy of conifers in Group 9 compared with Group 8 is also supported by the frequency data (Table 3-3) which indicates slightly higher frequencies in Group 9 for all of the conifer species with the exception of balsam fir – and in fact the frequencies of red and black spruce in Group 9 are significantly higher than for all of the plots combined. Correspondingly, and also agreeing with the biomass data, the frequencies for the broad-leaved species are less in Group 9.

The mean tree height and age for the two groups differed slightly, with the trees in Group 8 being taller by 70 cm and older by 2.5 years (Table 3-7). These differences however, were not great enough to be significant in the Scheffe test, and the assessment of stand age class (Table 3-12) also suggests only slight differences between the two groups - both contain the same proportion of immature stands (about 26%), with Group 8 having more mature stands (47% of stands), and Group 9 more uneven-aged stands (39%). The χ^2 test of association however, indicates that the age distribution of the stands differs little from that of all of the stands in general.

The 'actual density' of the trees in the two groups was in the middle range of the values for the groups (Table 3-7), with Group 8 (75%) being higher than Group 9 (67%). This agrees with the classification of the stocking rates of the stands (Table 3-12) – 67% of Group 8 stands were put in the highest stocking class (i.e. > 75%) compared with only 48% of the stands in Group 9, which had a notably high proportion of stands (40%) in stocking class 3 (i.e. 50 to 75%).

SHRUBS and SMALL TREES – Although they share in common most of the same shrub species, Group 9 had a higher total frequency of shrubs than did Group 8 (Table 3-8). Thus the number of frequent and selective species was higher for Group 9 : especially frequent were balsam fir, red maple and *Viburnum cassinoides*, while significantly associated with this group were *Nemopanthus mucronata*, *Viburnum cassinoides* and red spruce. Group 8 also contained these same species as shrubs but the only species selective for the group was balsam fir.

REGENERATION TREES – As was so for most of the other ground flora groups, only two species occurred at all frequently as small trees under 1.3 m height – balsam fir and red maple (Table 3-10); red spruce, although occurring at a lower frequency than these species, was selective for Group 9.

SITE CHARACTERS

The two groups have a similar distribution pattern on the Island (Appendix 1 : Group 8 and 9 maps; Table 3-12) – they occur in all three regions and are especially widely distributed in the western and eastern regions. Fewer plots occur in the central region than would be expected by chance, and these appear to be more common nearer the north coast than in the interior. In fact, their mean distances from the sea are virtually the same (5.3 and 5.2 km) – in the middle of the range for all of the groups (Table 3-21).

The mean elevation for Group 8 is higher than for Group 9 (28.0 m compared with 21.6) (Table 3-21). Both groups have similar mean slopes (1.7° and 1.5°) – which are on the low side in comparison with most of the other groups (Table 3-16); there is no association with any of the aspect classes, both groups making a very low contribution to the total χ^2 – the lowest of any of the groups. Having similar distances from the sea, both groups had similar corn heat unit values : 2302 and 2305 respectively (Table 3-21).

Each group shows the highest level of association with itself at the 240 sampling sites (Table 3-19), but they also showed a significant positive association with each other indicating they tend to occur together at the sites more frequently than would be expected due to chance. Group 9 also had a significant positive association with Group 14 (the dryer of the two black spruce - dominated forest-types). Both groups mostly had negative associations with the hardwood ground flora groups (Groups 5, 6 and 7).

The two groups are very similar in almost every category of their past management and history (Table 3-12). Of all the ground flora groups, these two have the greatest proportion of plots with evidence of clear- or partial-cutting – 49% for Group 8 and 51 % for Group 9, most of this being partial cutting. Group 8 had slightly more plots classified as 'old field' in the Inventory (17%) than did Group 9 (13.6%); however, the evidence from the 1935 aerial photo survey indicated the reverse : a smaller proportion of Group 8 plots were cleared land at that time (13.3%) compared with 19.5% for Group 9. Combining these two types of evidence suggests that each of them has a similar proportion of plots which were once cleared land – 24% for Group 8 and 30% for

Group 9. Overall, these two groups contributed very little to the total χ^2 value for past history, indicating that they have about the same class distribution as all of the plots taken together. Although they occur in a wide range of woodland sizes (Table 3-20), both groups have a similar and significant association with wooded areas of greater than 10 km^2. Group 9 has a slightly higher mean distance from roads or buildings (523 m compared with 471) (Table 3-21).

SOIL PROPERTIES

The soil textural classification for the two groups is virtually the same (Table 3-13) : with the exception of a possible slight association with clay soils, neither shows any notable association with any textural class. Most of the plots in both groups are well or moderately well drained. However, a higher proportion of plots in Group 8 are imperfectly drained – 21% compared with 4% in Group 9. There was however little evidence of a high water table affecting root development.

Both groups occurred on a wide range of soil series types (Tables 3-17, 3-18), but unlike the field assessment of soil drainage, the soil series analysis suggests that *both* groups have similar (and rather high) frequencies on imperfectly (13%) and poorly drained series (about 25%). Apart from a negative association with Charlottetown soils and a slight positive association with the Malpeque and Baptist Point series, Group 8 showed a rather low overall level of association with the specific soil series. Group 9 was more distinctive : it also had a similar negative association with the Charlottetown series and a slight positive one with Margate soils, but the notable point emerging is its high and significant association with the Culloden series – 25% of its soils were classed as such.

There is little difference between the two groups in any of their soil chemical properties (Table 3-14), and I will thus discuss them as a single unit. The pH value for the H horizon (4.2/4.0) is similar to that of many of the other groups, except for Groups 3, 13 and 14. Their organic matter contents (as evident from their percentage carbon) lie in the mid-range of group values (40 and 37%) – they are significantly higher than many of the other groups on mineral soils (especially Groups 6, 7 and 10), but lower than those with a high proportion of plots on organic soils (i.e. Groups 12, 13 and 14). It may be that their organic matter content has determined the levels of the macronutrients in their H horizons : all six nutrients in Groups 8 and 9 show more or less the same pattern – most being in the mid-range of values, and generally higher than those for Groups 6, 7 and 10. Potassium differs somewhat from this pattern in that the values for Groups 8 and 9 were higher than almost all other groups, and significantly so compared with several of them. This pattern however, does not hold for the micronutrients, with the possible exception of zinc (Table 3-15).

CONCLUSIONS

From the above data, I think we are justified in treating Groups 8 and 9 as a single ground flora type : together they represent a moderately species-rich vegetation-type in which the more ubiquitous and somewhat more acid-preferring species of Island woodland predominate. It is a group in which the tree canopy is dominated by conifer species rather than broad-leaves – especially important is balsam fir, followed by the spruces, with red maple being the chief broad-leaved species. The soils are generally dry with moderate levels of organic matter and soil nutrients.

It is not as easy to account for the factors responsible for this group as it was for the groups so far discussed, nor to equate them with any of the pre-European climax forest-types proposed by Erskine (1960) – the nearest is perhaps the lowland pine forest on sandy soils (Table 8), but pine is of little significance in this or any group – though it is notable that Group 9 is the group in which white pine attains its highest frequency and biomass even if at low levels (Tables 3-3, 3-5). It could be that what we have here is a ground flora community-type determined by a high level of human disturbance. Two different pieces of evidence support this view. The first is the high level of partial or clear-cutting in the two groups – it was the highest of any of the groups – 48.5 and 50.9% of plots. It could be that the greater disturbance associated with such human exploitation has lead to greater light penetration at the forest floor and a greater species diversity in comparison with the other dry forest types. The group may thus represent a type of frequently cut-over and disturbed forest occurring on drier soils.

The second piece of evidence relates to old-field succession : just over a quarter of the plots in the combined groups were formerly cleared land – these must be stands that have gone beyond the white spruce monoculture stage, to a further stage of succession in which species such as balsam fir, red spruce, red maple and white birch are now achieving dominance – a sort of 'second-generation' old field woodland which has established on such areas after the first generation white spruce woodland has either been cut or has fallen naturally. There was evidence supporting this view during the 1994 field visits – one of the Group 8 sites visited was clearly a second stage old field with moss-covered rotted stumps, presumably of white spruce, while the current tree canopy consisted largely of balsam fir with white birch and occasional white spruce.

However, despite the apparent importance of disturbance and succession as contributing factors to this vegetation-type, I do not think that we can rule out entirely the influence of innate site factors (i.e. soil properties) : the highly significant association of Group 9 plots with the rapidly-drained soil series (and specifically, the sandy Culloden series), supports this view. In fact it is possible that included in this group are the equivalents (or descendants) of a forest-type designated by Stewart (1806) as the worst land for agriculture – on which there was "nothing but spruce, small white birch and scrubby pines – the land [i.e. the soil] is generally light and sandy". Whether in 1806 he was referring to what was a successional vegetation-type and not climax forest, we cannot know. Nor can we know whether our combined Group 8 + 9 also now includes some of the sandy lowland sites that Erskine (1960) speculates were once dominated by a climax pine forest (Table 8).

We may thus have here a forest and ground flora type whose occurrence is due to several separate factors interacting with each other – i.e. poorer sandy soils and various types of human interference. Whatever its origin, it is obviously of importance in Island terms (25% of all the plots were in these combined groups). The complex possibilities for its origin suggest that there is not likely to be an easy 'arm-chair' way of mapping its present distribution. Even so I throw out a suggestion : if we were to map those stands which are conifer-dominated (i.e. conifers > 50%) – by summing covers for the principal conifer species (i.e. balsam fir, black spruce, red spruce, white spruce), omitting the first-generation old field white spruce stands (e.g. where white spruce was of > 60% cover), and also the black spruce - dominated bog and heath forests (i.e. Groups 13 and 14) (by using a similar percentage) we might end up with a map that would approximate to this vegetation-type.

GROUP 10

['Old field white spruce woods']

GROUND FLORA

Ground flora Group 10, comprising 135 plots (12% of plots), is a relatively species-poor group : 94 taxa were recorded, with a mean of 6.5 species per plot (Table 3-1). The most frequent species are ubiquitous species : *Pleurozium schreberi*, *Maianthemum canadense*, *Polytrichum commune* and *Trientalis borealis* – the two mosses achieving their highest frequencies in this group. A number of other species of little importance in other groups are characteristic and selective for this group : *Hieracium aurantiacum*, *Aster* spp., *Veronica officinalis* and *Myrica pensylvanica*.

TREE CANOPY

73% of the stands of this ground flora group were classed as >50% softwoods – with 45% having > 75% softwoods (Table 3-12). With a mean of 2.4 tree species per sampling plot (Table 3-3), this group had the third lowest tree species number of all of the groups – only Groups 13 and 14 were lower. The most frequent species was white spruce (in 85% of plots) followed by balsam fir and white birch. In terms of biomass contribution, conifers contributed 84%, with white spruce at 62% out-stripping all other species – balsam fir at 8% was a distant second, with small contributions by red spruce, black spruce and larch. The small contribution from broad-leaved species (15.6%) was largely split between trembling aspen, red maple and white birch. It is thus clear that we have here a ground flora group dominated by a single tree species – white spruce.

The mean height of the trees in this group was 14.9 m – as high as many other groups (Table 3-7); however, their mean age was only 44 years – the lowest of all the groups and significantly lower than most. This figure agrees with the classification of the ages of the stands (Table 3-12) : 43% were classed as immature – a much higher proportion than in any other group, while 16% were classed as uneven-aged, lower than any other group. The mean of the 'actual density' (83%) was higher than for many groups (Table 3-7) as was the proportion of stands placed in class 4, the highest stocking class (73%) (Table 3-12).

SHRUBS and SMALL TREES – Of all the groups, this one had the lowest total frequency for plants of shrub size (Table 3-8). One species (white spruce) was considerably more important than any other – it had a 59% frequency and was highly selective for the group. Of less importance were balsam fir and pin cherry.

REGENERATION TREES – There was relatively little tree regeneration in this ground flora group (Table 3-11). The most frequent regenerating species were balsam fir and red maple occurring in 17% of plots (Table 3-10) – a value lower than their frequency in many of the other groups. White spruce, although dominant in the tree canopy, occurred as a regeneration tree in only 10% of the plots.

SITE CHARACTERS

This ground flora group has a geographical bias towards the eastern end of the Island being especially prevalent in the eastern region, and within it, in the southern part (Appendix 1 : Group 10 map; Table 3-12). It is also common in the central region, but is significantly lower in the west. Its mean distance from the sea (6.7 km) is on the high side (Table 3-21).

The plots of this group have a high level of spatial association at the sampling sites with other plots of Group10 (39%) (Table 3-19) – the second highest level of self-association of any group (only Group 3 had higher). They also have a significant association with Group 11 plots – though numbers for this group were small – and negative associations with Groups 3, 5 and 6.

The mean elevation for Group 10 plots (36.1 m) is moderately high in comparison with other groups (Table 3-21). In terms of slope and aspect (Table 3-13) the plots are less frequent on level ground – only 18% were so, compared with 37% of all plots; those that sloped, face all directions with a slightly higher proportion facing the south-west than for the other ground flora groups. The mean slope of all the plots was 1.9° (Table 3-16) – which is in the middle range – as is the mean of the corn heat units for the plots (2308) (Table 3-21).

When we look at management and historical factors (Table 3-12), the most significant feature is the high proportion of plots classed as 'old field' in the Inventory – 59%. Aerial photo analysis indicates that an even higher proportion did not have forest cover in 1935 – 67%. Combining these two types of data gives 74% of plots as either clear land in 1935 or old field at some stage in their past. This is without doubt the most significant factor accounting for this ground flora group. Another management factor worthy of comment is the low proportion of plots (in comparison with other groups) showing evidence of either partial cutting/thinning or of clear cutting. Finally, the group shows no association with any particular woodland size class (Table 3-20), while the mean distance of the plots from roads or buildings (379 m) is among the lowest of all of the groups (Table 3-21).

SOIL PROPERTIES

All of the Group 10 plots occurred on mineral soils, but there was no association with any particular soil textural class (Table 3-13). There was a positive association with well-drained soils, with 84% of the plots occurring on such soils, while only 1.5% of plots were in the two poorer drainage categories. Thus, in none of the plots was there evidence of a high water table restricting root development. In fact, the mean rooting depth (62.5 cm) was the highest of all of the groups (Table 3-16), while the thickness of the A horizon (24 cm) was greater than most of the groups – with the exception of those which had a high proportion of plots on organic soils.

The soil series analysis (Tables 3-17, 3-18) also indicates a strong preference for dryer soils (86% occurred on well, moderately well and rapidly drained series), with a significant association with the rapidly drained Culloden series – 30% of the plots occurred on this series.

In terms of soil chemical properties (Tables 3-14), the group has a lowish pH – 4.2 for the humus layer, 5.2 for the B horizon – which is similar to many of the other non-organic groups. However, the organic matter content of the humus layer (24% – i.e. % carbon x 1.724) is the lowest of all the groups except Groups 6 and 7. Low organic matter levels may account for the similar low levels of nitrogen and sulphur, although the N : C level at 4.6% was in the middle range. Calcium and magnesium levels in the H horizon also tend to be on the low side compared with other groups. There is little to comment on for the micronutrients (Tables 3-15).

CONCLUSIONS

What we clearly have here is the ground flora group associated with the old field white spruce stands which are so common across the Island and especially in the east. With its species-poor ground flora in which there is a high frequency of mosses and of weedy non-woodland species, it is a vegetation-type easily distinquished in the field. The more ubiquitous native woodland species such as *Maianthemum canadense* and *Trientalis borealis* also occur. The tree canopy is species-poor being dominated entirely by white spruce, mostly even-aged and often immature yet of a high stocking rate and 'actual density'. Thus, the forest floor is likely to be heavily shaded – which has undoubtedly contributed to the paucity of species numbers. Also, because it is only in the last 60 years or so that most of the plots will have reverted to forest from cleared land, another factor contributing to the absence of many forest species may be the lack of sufficient time for successful colonization of the site.

It should be relatively easy to map the distribution of this vegetation-type on the Island, dominated as it is by a single tree species. In fact, the distribution maps showing forest stands where white spruce makes up at least 5% of the canopy probably already do so (Figure 7) – but in to order to exclude those vegetation-types where white spruce is a significant minority component (e.g. Groups 8 and 9) it would be preferable to set a much higher level for the cover value of white spruce in the stands to be mapped (e.g. 60%).

White spruce forest apparently only occurred as an important element in the pre-European forest along the coasts (Table 8) – and where the forest reaches to the shoreline at the present time it is still an important element in such areas. Johnstone (1822) gives a vivid description of this forest-type, especially the great difficulties in penetrating it from the seaward side, partly due to the accumulation over the years of many fallen trees blown over by the wind.

GROUP 11

['A species-poor hardwood-related plot type']

Group 11 is a small group (only 21 plots) which is particularly species-poor – a total of only 22 species were recorded, with a mean of only 4.0 species per plot (Table 3-1). As will be shown below, it appears to be a small group of hardwood plots that got separated in the TWINSPAN analysis from the main hardwood groups (Groups 5, 6 and 7), probably because it is very species-poor. The TWINSPAN data output indicates that nine of the 21 plots were listed as either 'mis-classified' or 'borderline' in the first division - which is a particularly high proportion. Even so, the field visits of 1994 do suggest that the group does have an ecological validity, even if on a rather small scale. I will discuss the group, but because of the small number of plots in the group, any conclusions carry less reliability than they do for the larger groups.

GROUND FLORA

This species-poor group is characterised by high frequencies of three moss species (*Dicranum scoparium, Pleurozium schreberi* and *Polytrichum commune*) (Table 3-1). Some of the ubiquitous species so common in many other groups also occur, but at levels less than in the other groups – *Maianthemum canadense, Trientalis borealis, Carex* species, and *Aralia nudicaulis*. The only selective species for the group is *Dicranum scoparium*, but the presence at low frequency of two species of less widespread occurrence (*Monotropa uniflora* and *Lycopodium obscurum*) is a pointer connecting this group to the hardwood groups.

TREE CANOPY

86% of the stands in which the plots occurred, were classified as hardwood-dominated – 62% of these being >75% hardwoods (Table 3-12) – a key piece of information indicating that this group belongs with the hardwood groups. However, the tree measurements (Table 3-5) indicate that in the variable-radius plots, conifer species contributed as much as the broad-leaved species to the total biomass – 53% compared with 48% for the broad-leaves, the greatest contribution being made by balsam fir, followed by white spruce and white birch. Beech and yellow birch together contributed 18% – another important indicator connecting these plots with the hardwood flora groups. The mean number of tree species per sampling plot was 3.4 (Table 3-3).

Some of the other tree measurements also connect this group with the hardwood groups. The mean height of the trees (high at 15.3 m) and their 'actual density' (a high 88.7%) are in agreement with the values for the hardwood groups (Table 3-7). The last figure is further supported by the assessment of the stocking rate of the stands : 90.5% were in the highest stocking class (>75%), and none were in either of the two lowest classes (Table 3-12). The mean age of the trees (53.2 years) was only slightly less than the means for the hardwood groups (Table 3-7), and in the age classification of the stands almost half were placed in the mature class (Table 3-12).

SHRUBS and SMALL TREES – This group had a moderate level of shrubs/small trees (Table 3-8) – with the species that were most frequent as trees also having the greatest frequency as shrubs : balsam fir, white spruce and white birch. White spruce and white birch, along with beech, were selective for the group.

REGENERATION TREES – There was also a moderate level of regeneration trees for the group (Table 3-10) with balsam fir and trembling aspen being the most frequent species. Only trembling aspen was selective for the group.

SITE CHARACTERS

Although the 19 sites at which the 21 plots occur have a wide geographical scatter (Appendix 1 : Group 11 map), there is clearly a clustering in the eastern region, especially in the south-east, and a sparsity of sites in the west. It is notable that 12 of these 19 sites also contained plots classified in either Group 6 or Group 7 – though the number of plots in Group 11 was not high enough for these spatial associations to be significant statistically (Table 3-19) – the group did in fact have statistically significant associations both with itself and with Group 10. The mean distance from the coast (5.6 km) is in the mid-range of values (Table 3-21).

The mean slope and elevation of the sites (2.0°, 42.2 m) (Tables 3-16, 3-21) are moderately high and similar to the values of the hardwood groups (2.1° to 2.4°, 36.9 to 50.4). Like them, the proportion of level plots is on the low side (Table 3-13), and there is an unusually high proportion of stands sloping to the south-east – a property which connects this group with Group 7. Its mean corn heat unit value (2311) is slightly lower than the hardwood groups (Table 3-21).

In terms of past management (Table 3-12), a high proportion of plots (43%) showed evidence of partial cutting or thinning, and 24% were classed as old field on the ground. Aerial photo analysis indicates a similar proportion (27%) were clear of trees in 1935, and when these two sources of information are combined a figure of 33% is obtained for the proportion of plots that were once cleared land. The group shows no particular association with any woodland size (Table 3-20); the mean distance of the plots from roads or buildings (495 m) is on the highish side (Table 3-21).

SOIL PROPERTIES

A notably high proportion of the plots (38%) occurred on loamy sands (Table 3-13) – a class not associated with any of the three hardwood groups, and all were either well or moderately well drained. The soil series analysis (Tables 3-17, 3-18) also indicates a high preference for the better drained soils – all but one of the 21 plots occurred on such series, and there was a significant positive association with Alberry soils.

The mean pH of the H horizon was 4.4 (Table 3-14) – which is similar to that of the hardwood groups, as were also the levels of carbon, nitrogen, sulphur, calcium and magnesium. However, phosphorus and potassium values were a little higher than in the three hardwood groups.

CONCLUSIONS

The tree data, especially the high proportion of stands classified as hardwood-dominated (HH), and the high presence level and biomass contribution of beech and yellow birch, suggest that we have here a small group of plots belonging with the hardwood groups which have got separated from them because of their low species number. The high presence of moss species suggested that light may be the controlling factor responsible for the paucity of their flora – the high 'actual density' and stocking rate supporting this. This was confirmed by the field visits of 1994 – the plots visited were dominated by balsam fir thickets casting a greater shade than in the surrounding areas under broad-leaved trees.

Thus this small group is best considered as an off-shoot of the dry hardwood ground flora groups. Apart from the factors (probably always localized) which have led to the paucity of its ground flora, and thus the 'mis-classification' of these plots in the first division of the TWINSPAN analysis, it would seem, from the small number of plots classified as such, to have limited ecological applicability.

GROUP 12

['A wet transition plot type']

Group 12 contains only twelve plots, and like Group 11, appears to be a group that may have fallen on the 'wrong' side in the first TWINSPAN division (Figure 2), and then was thrown out as a small group in a later division. As I shall demonstrate, it shares many of its species and properties with Group 3; however, at the same time, unlike the plots in Group 3, it overlaps in its species make-up with Groups 13 and 14.

GROUND FLORA

Group 12 is a species-rich group : a total of 55 species were recorded in the 12 plots, with a mean of 13.9 species/plot – as high a value as for Group 3, and much higher than all the other groups. As is evident from Table 3-1, many of the species it contains are also frequent in Group 3 and in no other group – those of higher frequency are *Osmunda cinnamomea, Rubus pubescens* and *Carex* species. But it also contains high levels of a number of species absent from Group 3 but prevalent in Groups 12 and 13 : *Kalmia angustifolia*, *Nemopanthus mucronata*, *Smilacina trifolia*, and at lower frequency levels, *Vaccinium angustifolium*, *Vaccinium myrtilloides* and *Ledum groenlandicum* – and it is undoubtedly the presence of these species which has lead to the separation of these plots from the Group 3 plots in the first division of the TWINSPAN analysis. It thus appears to contain a mixture of two species-groups not occurring together very often (only 12 plots were in the group), and is likely to be a transition group between Group 3 and Groups 13 and 14 – which is exactly its location on the DECORANA ordination (Figure 4).

TREE CANOPY

Eight of the stands on which the twelve plots occurred were classed as softwood-dominated (i.e. >50% softwoods) (Table 3-12). The mean number of tree species per plot was 3.2, the most frequent species being black spruce, followed by red maple, balsam fir and larch (Table 3-3). Conifers contributed 65% of the total biomass (Table 3-5), the greater part of this coming from balsam fir, black spruce and red spruce. Of the 35% contributed by broad-leaves, almost all of this was from red maple, whose individual contribution exceeded that of any of the conifer species. The tree species data is thus not dissimilar to that of Group 3 – apart from a higher frequency and biomass contribution by black spruce.

The mean height of the trees (13.5 m) was a metre less than that of Group 3, while their mean age (68 years) was greater by eight years (Table 3-7). This latter difference is supported by the assessment of the age class of the stands (Table 3-12) : 75% were classed as either mature or over-mature – compared with 54% for Group 3. The assessment of the stocking rate of the stands gave values not dissimilar to that of Group 3. However, the mean 'actual density' in the sampling plots (Table 3-7) turned out to be considerably less than Group 3 – 50% compared with 69% – Group 12's value in fact being close to that of Group 14.

SHRUBS and SMALL TREES – This group had a comparatively high total frequency for shrubs/small trees (Table 3-8). Most of the species prominent as trees were also important as shrubs, with black spruce being both the most frequent and most selective for the group. In addition, several shrub species not occurring as trees were also frequent in the group – alder, *Ilex verticillata* and *Nemopanthus mucronata*.

REGENERATION TREES – Unlike Group 3, this group had a comparatively high total frequency of regenerating tree species (Table 3-10). The most frequent species were the ubiquitous red maple and balsam fir, while larch, and to a lesser extent red maple, were selective for the group.

SITE CHARACTERS

Group 12 plots occur mostly in the eastern region (Appendix 1 : Group 12 map) – seven of the ten sites at which the twelve plots occurred were in the east, and at five of these sites Group 3 plots also occurred – though not at a level that was statistically significant (Table 3-19) – the small number of plots in Group 12 precluding this. The mean distance of the plots from the sea (7.7 km) is very high – due to four of the plots in the eastern region being over 12 km from the coast – which also likely accounts for their moderately high mean corn heat unit value (2306) (Table 3-21).

The mean elevation of the plots (25.2 m) is on the low side (Table 3-21), and with ten of the twelve plots being on level ground (Table 3-13), the overall slope is also low (1°) – the lowest of all the groups (Table 3-16). In terms of management and site history (Table 3-12) the most notable feature is that eight of the twelve plots were classed as 'swampy' – the highest proportion of any of the groups, the nearest being Groups 13 and 3. Three of the twelve plots had evidence of partial cutting or thinning – a proportion also similar to that of both Groups 3 and 13. All but two of the plots occurred in woods of greater than 5 km^2 (Table 3-20), but because of the small number of plots in the group this association was not significant. The mean distance of the plots from roads or buildings (392 m) is on the low side (Table 3-21).

SOIL PROPERTIES

Five of the twelve plots occurred on organic soils (Table 3-13), while nine of the twelve plots were poorly-drained, with an additional two, imperfectly-drained; a high water table was restricting root development in seven of the twelve plots. This prevalence of wet organic soils is similar to both Groups 3 and 13 – and especially the latter. The soil series analysis (Tables 3-17, 3-18) also showed a significant association with poorly drained soil series – 67% of plots occurring on such soils.

The mean pH of the soils – 4.9 in the H horizon and 5.6 in the B (Table 3-14) – was much higher than any other group except Group 3, and notably, it was significantly higher than Groups 13 and 14. This group also had the highest percentage carbon in the H horizon (37.8%), a value much greater than Group 3 – and significantly so, but similar to that of Groups 13 and 14. The high organic matter content is likely to be the factor contributing to the high nitrogen and sulphur contents of the H horizon (the highest of any group). The levels of total calcium and magnesium in the H horizon were also (like those of Group 3) very high, while phosphorus and potassium were among the lowest – a feature this group also shares with Group 3. Thus in terms of its soil properties, this group, apart from its very high organic matter content, is most similar to Group 3.

CONCLUSIONS

Group 12 thus shows close associations with Group 3 – in addition to the great overlap in ground flora composition, the two groups also share many of their other properties – notably those of their tree canopies, their geographical distribution, and their soil properties. However at the same time, Group 12 has a similarity in some of its properties to Groups 13 and 14 (especially Group 13) which would account for the presence of many species also found in those groups. Group 12 is thus probably best thought of as a small group of plots which represent a transition between the two ground flora and habitat types – which is exactly where it is located on the DECORANA ordination (Figure 4). This was also exactly what was observed in the field in 1994 : at the site visited the first plot along the cruise line was in vegetation typical of Group 3 while the third plot was typical of Group 13 – in between them, in the area of the second plot (which had been classified as Group 12) was an area containing a fairly intimate mixture of species typical of the two different groups – notably *Rubus pubescens*, *Onoclea sensibilis*, *Osmunda cinnamomea*, *Cornus stolonifera*, and *Galium triflorum*, (typical of Group 3) mixed with Group 13's *Ledum groenlandicum*, *Cypripedium acaule*, *Vaccinium myrtilloides*, *Gaultheria hispidula* and *Kalmia angustifolia*. *Sphagnum* species (common to both groups) were also present.

GROUPS 13 and 14

['Black spruce 'bog' and 'heath' forests']

These two groups comprise respectively 29 and 51 plots (7.1% of the total). Because they overlap extensively in species composition (especially in the dominance of the tree canopy by black spruce), they are discussed here together. However, the differences between them are very evident in the field and are of ecological significance.

GROUND FLORA

The mean number of species per plot was the same for both groups – 8.9 species, with a total of 43 species being recorded for Group 13, and 52 for Group 14 (Table 3-1). As a combined group they are jointly characterised by the presence at high levels of *Kalmia angustifolia, Vaccinium angustifolium, Ledum groenlandicum, Nemopanthus mucronata, Vaccinium myrtilloides*, and *Gaylussacia baccata*. A number of more ubiquitous species are also common to both groups, some at high frequency levels – *Pleurozium schreberi, Cornus canadensis, Viburnum cassinoides, Dicranum polysetum, Polytrichum commune*, and at lower levels, *Maianthemum canadense* and *Trientalis borealis*. What distinquishes the two groups from each other is the presence/abundance of a number of particular species in each group : Group 13 is characterised by higher levels of *Carex* species, *Sphagnum* species, *Gaultheria hispidula, Cypripedium acaule, Clintonia borealis, Smilacina trifolia* and *Osmunda cinnamomea*, while Group 14 has higher levels of *Pteridium aquilinum, Rhododendron canadense, Gaultheria procumbens, Cladina rangiferina, Ptilium crista-castrensis, Epigaea repens, Amelanchier* species, and *Cladina stellaris*. These differences in species appear to reflect a real difference in the two ground flora groups, which as I shall outline below, can be accounted for in environmental terms. However, because of the extensive overlap in plant species between them, I shall consider them as two variants – even if distinct – of a single vegetation type.

TREE CANOPY

The stands in which the two groups occur were overwhelmingly softwood-dominated (Table 3-12) – 86 and 94% of stands were either SS or SH (i.e. > 50% softwoods), and conifers accounted for 96 and 93% of the total biomass (Table 3-5). Both groups were significantly species-poorer in trees than the other ground flora groups with only 2.2/2.0 tree species per sampling plot (Table 3-3). By far the most important tree species was black spruce – it had both the highest frequency in both groups (76 and 61% respectively) and made the greatest contribution to total biomass (57 and 51%). Other conifers make up the balance – larch being the most important in Group 13 followed by red spruce, while red spruce led the other conifers in Group 14. There were smaller contributions by white spruce and balsam fir in each group. Broad-leaved species made virtually no contribution to biomass, and there was only the occasional presence of red maple, white birch or trembling aspen.

The mean height of the trees was 11.9 metres in Group 13 and 12.6 in Group 14 – significantly lower than any of the other groups except Group 12 (Table 3-7). Their mean ages were 54 and 57 years – which is on the lowish side compared with many of the other groups. The age classification of the stands (Table 3-12) indicated that about a third of the stands in each group were immature, with Group 13 having a higher proportion of mature stands than Group 14, which had more unevenaged stands – over a fifth of its plots were in this class.

The mean of the 'actual density' for the two stands was lower than for most other groups (Table 3-7), with Group 14 having a far lower value than Group 13 – 48% compared with 61%. Despite this difference between them, the stocking rates of their stands were about the same (Table 3-12) – both groups having a higher proportion of stands in the second lowest stocking class (class 2) than all the other ground flora groups except Groups 3 and 12 – which is in agreement with their low 'actual densities'.

SHRUBS and SMALL TREES – Group 13 had a higher total frequency of shrubs than Group 14 (Table 3-8) and although there was a considerable overlap in species make-up between the two groups, they differ in certain species. As was so for the tree canopy, black spruce had the highest frequency as a shrub in both groups, and *Viburnum cassinoides* was also significantly associated with each group. However, Group 13 differed from 14 in terms of its high and significant frequencies of larch and *Nemopanthus mucronata*, while Group 14 had a higher frequency of red spruce.

REGENERATION TREES – For both groups the two species with the highest frequency as regeneration trees were black spruce and red maple (Table 3-10), with the frequency of black spruce in each of the two groups being significantly higher than in all the other groups taken as a whole. Regenerating red spruce, though at a lower frequency level, was also significantly associated with Group 14.

SITE CHARACTERS

These groups exhibit a distinct geographical pattern with a greater occurrence at the two ends of the Island (Appendix 1 : Group 13 and 14 maps). Although the two groups overlap in their distributions there are differences : Group 14 has a greater mean distance from the coast (5.5 km compared with 3.6) (Table 3-21) and is more prevalent in the eastern region – almost 69% of the plots occur in this region (Table 3-12), and they are especially concentrated beween the Cardigan and Fortune Rivers. It is also found in the west especially in the area of the Egmont-Cascumpeque isthmus, but it is largely absent in the central region occurring there only in the Covehead and Tracadie Bay areas. Group 13 occurs in some of these same areas, often at the same sites – there is a notable cluster in the peninsula inland from Launching Point in the eastern region, and a wider, if sparse, scatter in the central region. Both groups showed the highest level of spatial association with other plots of the same group, but they were also significantly associated with each other (Table 3-19); in addition Group 14 showed a significant association with Group 9.

In slope and elevation the notable features are the low mean elevations of both groups (19.1 and 19.6 m) (Table 3-21) and the high proportion of stands on level ground – 93% of Group 13's plots and 67% of Group 14's (Table 3-13). Their mean slopes, at 1.6° and 1.5°, are on the moderate to low side in comparison with the other groups (Table 3-16). Their low elevation and relative closeness to the sea probably account for the fact that they have the lowest mean corn heat units for all of the groups (2288 and 2284) (Table 3-21).

In terms of the past history and origin of the stands (Table 3-12), the most notable feature is the high proportion of Group 13 stands (24%) that were classed as 'swampy' in origin – by contrast only 3.9% of Group 14's stands were so classed. However, 16% of Group 14's stands were classed as 'bog' (they comprise the 'Other' category in Table 3-12) – compared with only two (i.e. 7%) of Group 13's stands – this may reflect a real difference in the perception of the stands. Otherwise, there was evidence of partial cutting or thinning in 27% of Group 13 and 20% of Group 14 stands. On the ground, both groups were assessed as having the same proportion of old field sites (about 10%). A higher proportion than this was cleared land in 1935 as determined from analysis of the aerial photo survey (about 21%), and combining the two sources of information indicates that just over a quarter of the plots in both groups were once cleared land. Apart from the swamp/ bog difference both groups thus appear to be very similar in terms of their past history or origin. There are however differences in terms of woodland size (Table 3-20) : Group14 has a significant positive association with woods of greater than 10 km^2 and a corresponding negative association with woods of less than 5 km^2, while by contrast Group 13 shows no association with any particular woodland size. They also differ in the mean distance of the plots from roads or buildings (Table 3-21) – but not in the way predicted from the woodland sizes – Group 13's distance (496 m) was moderately high, while Group 14 had the lowest distance of all of the groups (284 m).

SOIL PROPERTIES

A striking difference emerges from the soil texture analysis of the sites (Table 3-13) : 31% of the Group 13 plots were on organic soils compared with only 2 % of the Group 14 plots. Both groups have a negative association with loamy soils – otherwise most soil textural groups are represented. The assessment of soil drainage indicates another big difference : a much higher proportion of Group 13's soils are poorly drained than Group 14's (69% compared with 24%) – and when the imperfectly-drained class is also considered, the total for Group 13 is almost 90% while only 53% of Group 14's plots are either poorly or imperfectly drained. This agrees with the water table assessment : in 31% of Group 13's plots, root development was restricted by a high water table, compared with only 4% of Group 14's. Average rooting depths however, though slightly less than for most of the other groups, showed little difference between the two groups (Table 3-16). However the A horizon thickness was greater in Group 13.

The soil series analysis (Tables 3-17, 3-18) is in broad agreement with that determined in the field : Group 13 has a statistically significant association with poorly drained series (72% of its plots occurred on such series) with the specific associations with the Mossy Point, Orwell and Winsloe series being statistically significant. Group 14 had a lower proportion of plots associated with poorly drained series (45% – which was still significantly high) and a higher proportion on Culloden and other rapidly drained series (23.5% compared with 3.4% for Group 13). Both groups had negative associations (mostly statistically significant) with the Charlottetown and Alberry series.

Turning to the soil chemical properties (Table 3-14), these two groups had the lowest pH in the H horizon (3.9) of all eleven groups. Thus it is not surprising that their organic matter contents, as indicated by their percentage carbon (33.7/29.7), were significantly higher than all of the groups except Group 12. However, the macronutrient levels are not proportionately higher – their absolute levels of nitrogen are similar to most of the other groups except the higher Groups 3 and 13, but when these are expressed in relation to organic matter content these two groups have the lowest N : C ratio of all of the groups, and inversely, the highest C : N ratio. Sulphur and potassium also appear to be higher in absolute terms, but when they are expressed in relation to the organic matter content, their sulphur contents are lower than most, and their potassium content is only higher than that of Groups 3 and 12.

CONCLUSIONS

These two groups contain the ground flora predominant in the black spruce forests of the Island, further subdivided into a dry and wet forest type. Despite the great overlap in species composition between Groups 13 and 14 (Table 3-1), the field visits to particular sites indicated that there was a very distinctive difference in the appearence of these two types of vegetation – a difference that appears to be clearly related to moisture levels : the ground flora of Group 13 was dominated by mosses, especially species of *Sphagnum* as well as *Pleurozium schreberi*, whereas Group 14 was characterised by a more open habitat and a preponderance of heath shrubs – its ground flora did include many of the moss species present in Group 13 but they were less prominent, and a key difference was the prevalence of lichen species – notably *Cladina rangiferina* and *C. stellaris*.

Despite the extensive overlap in their species composition (including the dominance of black spruce in the canopy of both sites), we thus appear to have here two different types of forest – and the distinquishing factor seems to be the mositure level of the sites : on the wetter Group 13 sites we have in effect a black spruce (+ larch) *bog* forest, while on the Group 14 sites, which include a higher proporton of drier soils (many even of the rapidly drained Culloden soils) we have a black (+ red) spruce - dominated *heath* forest. These two types of forest have been distinquished elsewhere where they cover much larger areas of ground (e.g. in New Brunswick, vegetation types equivalent to these two groups are evident in the Forest Site Classifiction for the Harvey-Harcourt Region (Zelazny *et al*. 1989) On the Island they comprise jointly only 7.1% of all plots.

If we were to attempt to map the distribution of these forest-types on the Island a starting point would be the 1990 map showing the distribution of stands in which black spruce contributed a minimum of 5% to the tree canopy (Figure 7) – if we were to assign a much higher minimum level to the black spruce (e.g. 50%), this should eliminate the other vegetation-types in which black spruce makes a notable contribution (e.g. ground flora Groups 8 and 9 – see Table 3-5). Also, using this tree canopy data further, it may be possible in the mapping to distinguish Groups 13 and 14 – e.g. mapping as Group 13 all those black spruce stands in which larch contributes a selected minimum, e.g. ≥ 10% (see Table 3-5); and as Group 14 those stands where red spruce contributes e.g. ≥ 15%. And the soil survey maps may be of some use in distinquishing the two groups

– though as was noted previously for other groups, there is not an exclusive relationship between either of these ground flora groups and any particular soil series (see Table 3-17) – all the same, the close association of Group 14 with Culloden soils may be of some use in such a mapping process.

Because of the very poor nutrient status and/or wetness of the soils on such sites, it is most likely that almost all of the areas covered by these forest types at the time of European settlement are still forest-covered, and thus any map that we produce to show their present-day distribution is likely to equate well with their pre-European distribution. There are some historical references to what clearly seems to be the wetter of these two black spruce forest types : "swamps that produce nothing but small black spruce trees" (Stewart 1806), "swamps ... growing with black spruce, so rank as not to be more than a foot apart ..." (Johnstone 1822); for the dryer forests it is possible that their pre-European ancestor may have been grouped by Stewart in his 'worst land' category – i.e. "that which produces nothing but spruce, small white birch and scrubby pines, this land [is] generally very light and sandy". As we noted before, this description could also apply to the ancestors or equivalent of the Group 9 plots – and the overlap between Groups 9 and 14 in the DECORANA ordination is a clue to their similarity (Figure 4).

APPENDIX 3

Tables presenting detailed analytical and statistical comparisons of the vegetation and environmental properties of the eleven principal TWINSPAN groups generated at the fourth division level. The data contained in these tables has been summarised in the group descriptions of Appendix 1 and is fully discussed in Appendix 2. The following is a list of the tables, summarizing the information they contain for each TWINSPAN group :

TABLE 3-1.	The percentage frequency of the ground flora species.
TABLE 3-2.	Frequency classes of the ground flora species.
TABLE 3-3.	The percentage frequency of the tree species in the variable-radius plots.
TABLE 3-4.	Frequency classes of the tree species.
TABLE 3-5.	The mean of the percentage contribution of each tree species to the total tree biomass.
TABLE 3-6.	Class table for the mean percentage contribution of the different tree species to the total tree biomass.
TABLE 3-7.	The mean height, age and 'actual density' of the trees.
TABLE 3-8.	The percentage frequency of the shrubs and small trees.
TABLE 3-9.	The mean number of shrubs and small trees (per 16 m^2 plot).
TABLE 3-10.	The species percentage frequency of the regeneration trees.
TABLE 3-11.	The mean number of regeneration trees (per 4 m^2 plot).
TABLE 3-12.	General stand and site attributes.
TABLE 3-13.	Qualitative field soil properties and aspect.
TABLE 3-14.	The mean values for pH, carbon and soil macronutrients.
TABLE 3-15.	The mean values for the soil micronutrients.
TABLE 3-16.	The mean values for soil profile measurements and slope.
TABLE 3-17.	The soil series for the 1200 Inventory plots subdivided according to ground flora TWINSPAN groups.
TABLE 3-18.	The principal soil series of the ground flora TWINSPAN groups.
TABLE 3-19.	The spatial association of the different ground flora TWINSPAN groups at the 240 sampling sites.
TABLE 3-20.	The woodland area sizes.
TABLE 3-21.	Four attributes assessed from maps (distance from the coast, distance from nearest road, elevation and corn heat units).

TABLE 3-1. The percentage frequency of the ground flora species in the different ground flora TWINSPAN groups (TWINSPAN groups having less than ten plots have been omitted). Only species with ≥ 5% frequency in at least one group have been included - excluding those species only attaining this frequency level due to a single occurrence in the smallest group (Group 12). For the species listed, only values ≥ 5% are given. Frequencies printed in bold were significantly greater (X^2 test, df = 1, $p<0.01$) than the frequency for the same species in all 1200 Inventory plots. The species are listed in the same order as in the data matrix table generated by the TWINSPAN analysis, with those species not listed in that table (mostly the genera) inserted at appropriate points as judged by eye.

SPECIES	GROUND FLORA TWINSPAN GROUP											All 1200 Plots
	3	5	6	7	8	9	10	11	12	13	14	
Alnus rugosa	**12**								**25**			2.9
Aster umbellatus	**16**				7	7			17	10		5.4
Ilex verticillata	**6**								**25**	7		2.1
Ptilidium pulcherrimum	**13**	6			5	5						4.6
Rosa virginiana	**6**											1.7
Rubus allegheniensis										7		1.5
Aster puniceus	**18**		6				9		**8**			5.5
Dryopteris cristata	**8**								**33**			2.0
Viola spp.	8						7		**33**			4.2
Epilobium angustifolium	**15**		6			6						5.2
Equisetum spp.	**12**											2.8
Equisetum sylvaticum	**15**								**8**			3.0
Equisetum arvense	**8**											1.5
Fragaria virginiana	**33**					5	6		25			7.7
Galium triflorum	**33**		**9**				7		**8**			7.3
Lonicera canadensis	**6**											1.4
Ranunculus repens	**30**						5					3.8
Rhytidiadelphus triquetrus	**26**								25			5.2
Ribes glandulosum	**6**											1.5
Rubus pubescens	**69**		5		**8**				**80**			12.4
Circaea alpina	**7**								**8**			1.3
Lycopus uniflorus	**18**											1.7
Osmunda cinnamomea	**35**				7				**75**	17		7.9
Typha latifolia	**6**								17			1.1
Athyrium filix-femina	**28**	6							**8**			5.4
Caltha palustris	**7**											0.9
Cornus stolonifera	**30**								17			4.8
Eupatorium maculatum	**8**								**8**			1.3
Galium palustre	**13**											1.8
Impatiens capensis	**44**								25			6.3
Mitella nuda	**31**								**8**			4.8
Mnium spp.	**31**								**8**			5.0
Onoclea sensibilis	**36**								**8**			5.3
Prunus virginiana	**8**								**8**			1.3
Ribes hirtellum	**8**											1.1
Ribes lacustre	**14**								**8**			2.3
Thalictrum polygamum	**10**											1.5
Gymnocarpium dryopteris	**17**											3.3
Thelypteris phegopteris	**18**											2.0
Corylus cornuta	**8**											2.8
Acer spicatum	**6**	**18**										2.6
Taxus canadensis	**28**	**64**	9	6	7				17			11.2
Dryopteris spinulosa	**42**	**92**	**39**	31	**19**	5						26.3
Oxalis montana	5	**13**	6									2.9
Sambucus pubens		6	**6**									2.6
Streptopus roseus			**6**									2.6
Viola cucullata	10		**8**	6			5		**8**			4.8
Viola pallens	**33**	6	**31**	19	**12**	**9**	7					16.3
Dennstaedtia punctilobula			15	**67**	**12**							14.6
Lycopodium annotinum				**33**								4.4
Lycopodium lucidulum		5		**10**								2.8
Lycopodium obscurum		14	13	**63**	10	**18**		**19**				15.3
Medeola virginiana				**14**								2.7

SPECIES	GROUND FLORA TWINSPAN GROUP											All 1200 Plots
	3	5	6	7	8	9	10	11	12	13	14	
Smilacina racemosa			**8**	**9**								2.8
Trillium undulatum		14	**33**	**44**	10	8	5					15.3
Viola incognita			**10**	**9**			5					3.8
Aralia nudicaulis	29	44	**56**	45	**53**	19	7	10	8			32.5
Monotropa uniflora				**7**				10				2.2
Prenanthes trifoliolata	8		9	8		5						5.2
Rubus canadensis	12	9	**16**		8		7					8.5
Rubus strigosus	6		9	7								4.7
Aster acuminatus	13	6	**34**		17	8						10.0
Pyrola elliptica	10		6	5	7		5		8			5.0
Cornus alternifolia			**6**									1.2
Trientalis borealis	31	27	**66**	**63**	**60**	51	36	33	33	7	10	44.3
Clintonia borealis	15	26	**35**	9	**47**	13				28		19.8
Coptis groenlandica	**19**		8		22	14			**80**	14	6	10.6
Grass spp.	**18**		6				**16**					7.6
Solidago spp.	7						6		9			3.3
Dicranum scoparium	8	14	21	16	**41**	24	13	**100**	8	7	6	19.8
Lycopodium clavatum		9		7	**9**	5						4.3
Moss spp.	5	6	7	6			6	10				4.8
Maianthemum canadense	32	38	**74**	**77**	**85**	**92**	56	**48**	33	10	18	58.8
Sorbus americana	9		**15**		**15**	5	12			7		8.3
Hieracium aurantiacum							**19**					5.1
Hieracium canadense							**5**			7		1.6
Polytrichum commune			7	20	23	**37**	**46**	29		10	25	19.0
Aster spp.	5						**14**					4.2
Veronica officinalis							**13**					3.2
Amelanchier spp.			10		**15**	**18**	7		17		16	8.3
Bazzania trilobata					**5**							1.8
Cornus canadensis	27	25	29	9	**61**	**86**	10		83	59	57	35.2
Cypripedium acaule										**31**	**10**	2.8
Hylocomium splendens	12				**16**		7		**58**	17	6	6.7
Linnaea borealis	11				**33**	**22**			8			10.2
Pteridium aquilinum			8	11	19	**73**			8		**49**	16.8
Viburnum cassinoides	20		5	7	**63**	**58**	21		67	45	**49**	26.8
Dicranum polysetum					**20**	15	**19**		8	14	**45**	10.1
Epigaea repens						**11**					**18**	2.2
Melampyrum lineare						5	6		8		**18**	2.5
Myrica pensylvanica							**5**			7		1.4
Carex spp.	**44**	8	23	15	19	16	25	14	58	**48**		22.3
Pleurozium schreberi	25	8	13	9	**72**	**69**	**82**	71	75	72	**80**	41.8
Ptilium crista-castrensis						7	**16**		17		**18**	4.3
Vaccinium angustifolium					15	**68**	**26**		25	21	**69**	14.8
Vaccinium myrtilloides					12	**31**	7		17	**31**	**31**	8.2
Cladina rangiferina											**25**	1.8
Gaultheria procumbens						6				7	**31**	2.7
Gaylussacia baccata										**21**	**18**	1.3
Kalmia angustifolia					7	**46**			**58**	**66**	**90**	13.8
Ledum groenlandicum									17	**31**	**37**	2.8
Nemopanthus mucronata					**31**	7			**43**	**73**	**22**	8.1
Chamaedaphne calyculata										**14**		0.6
Rhododendron canadense										10	**35**	2.3
Gaultheria hispidula	5								8	**41**	**8**	3.1
Smilacina trifolia									**58**	**17**		1.7
Sphagnum spp.	29				17				**92**	**97**	**35**	13.0
Cladina stellaris											**13**	0.7
Number of plots	156	77	196	155	165	118	135	21	12	29	51	1200
Mean number of species/plot	13.7	5.6	7.7	6.9	9.8	9.5	6.5	4.0	13.9	8.9	8.9	8.6
Standard error (±)	0.44	0.34	0.23	0.20	0.29	0.27	0.29	0.44	2.2	0.60	0.38	0.13
Scheffe test*	a	abcdeg	abcdg	abcd	ab	ac	abcd	abcdefg	d	af	ag	

*One-way ANOVA (df = 10) F = 53.0, $p<0.001$. Means with the same letter are significantly different from a mean with an underlined letter, 'a' is significantly different from 'a' (Scheffe multiple comparison test, $p<0.05$).

TABLE 3-2. Frequency classes of the ground flora species in the ground flora TWINSPAN groups. Only species of ≥ 10% frequency in at least one group are listed. Frequency classes printed in bold had a significantly greater percentage frequency (χ^2 test, $p<0.01$) than for the same species in all 1200 plots. See footnote 2 for frequency class sizes.

SPECIES	GROUND FLORA TWINSPAN GROUP										
	3	5	6	7	8	9	10	11	12	13	14
Alnus rugosa	**I**								**II**		
Aster umbellatus	**I**				•	•			I	I	
Ilex verticillata	•								**II**	•	
Ptilidium pulcherrimum	**I**	•			•	•					
Aster puniceus	**I**		•				•		•		
Dryopteris cristata	•								**II**		
Viola spp.	•						•		**II**		
Epilobium angustifolium	**I**		•			•					
Equisetum spp.	**I**										
Equisetum sylvaticum	**I**								•		
Fragaria virginiana	**II**					•	•		II		
Galium triflorum	**II**		•				•		•		
Ranunculus repens	**II**						•				
Rhytidiadelphus triquetrus	**II**								II		
Rubus pubescens	**IV**		•		•				**III**		
Lycopus uniflora	**I**										
Osmunda cinnamomea	**II**				•				**IV**	I	
Typha latifolia	•								I		
Athyrium filix-femina	**II**	•							•		
Cornus stolonifera	**II**								I		
Galium palustre	**I**										
Impatiens capensis	**III**								II		
Mitella nuda	**II**								•		
Mnium spp.	**II**								•		
Onoclea sensibilis	**II**								•		
Ribes lacustre	**I**								•		
Thalictrum polygamum	**I**										
Gymnocarpium dryopteris	**I**										
Thelypteris phegopteris	**I**										
Acer spicatum	•	**I**									
Taxus canadensis	**II**	**IV**	•	•	•				I		
Dryopteris spinulosa	**III**	**V**	**II**	II	I	•					
Oxalis montana	•	**I**	•								
Viola cucullata	I		•	•			•		•		
Viola pallens	**II**	•	**II**	I	I	•	•				
Dennstaedtia punctilobula			I	**IV**	I						
Lycopodium annotinum				**II**							
Lycopodium lucidulum		•		**I**							
Lycopodium obscurum		I	I	**IV**	I			I			
Medeola virginiana				**I**							
Trillium undulatum		I	**II**	**III**	I	•	•				
Viola incognita			**I**	•			•				
Aralia nudicaulis	II	III	**III**	III	**III**	I	•	**I**	•		
Monotropa uniflora				•				**I**			
Rubus canadensis	I	•	**I**		•		•				
Aster acuminatus	I	•	**II**		I	•					
Pyrola elliptica	I		•	•	•		•		•		
Trientalis borealis	II	II	**IV**	**IV**	**IV**	III	II	II	II	•	I
Clintonia borealis	I	II	**II**	•	**III**	I				II	

SPECIES	GROUND FLORA TWINSPAN GROUP										
	3	5	6	7	8	9	10	11	12	13	14
Coptis groenlandica	I		•		II	I			III	I	I
Grass spp.	I		•				I				
Dicranum scoparium	•	I	II	I	III	II	I	V	•	•	•
Moss spp.	•	•	•	•			•	I			
Maianthemum canadense	II	II	IV	IV	V	V	III	III	II	I	I
Sorbus americana	•		I		I	•	I			•	
Hieracium aurantiacum							I				
Polytrichum commune			•	II	II	II	III	II		I	II
Aster spp.	•						I				
Veronica officinalis							I				
Amelanchier spp.			I		I	I	•		I		I
Cornus canadensis	II	II	II	•	IV	V	I		V	III	III
Cypripedium acaule										II	I
Hylocomium splendens	I				I		•		III	I	•
Linnaea borealis	I				II	II			•		
Pteridium aquilinum			•	I	I	IV			•		III
Viburnum cassinoides	II		•	•	IV	III	II		II	III	III
Dicranum polysetum					II	I	I		•	I	III
Epigaea repens						I					I
Melampyrum lineare						•	•		•		I
Carex spp.	III	•	II	I	I	I	II	I	III	III	
Pleurozium schreberi	II	•	II	•	IV	IV	V	IV	IV	IV	V
Ptilium crista-castrensis						•	I		I		I
Vaccinium angustifolium					I	III	II		II	II	IV
Vaccinium myrtilloides					I	II	•		I	II	II
Cladina rangiferina											II
Gaultheria procumbens						•				•	II
Gaylussacia baccata										II	I
Kalmia angustifolia					•	III			III	IV	V
Ledum groenlandicum									I	II	II
Nemopanthus mucronata					II	•			III	IV	II
Chamaedaphne calyculata										I	
Rhododendron canadense										I	II
Gaultheria hispidula	•								•	III	•
Smilacina trifolia									III	I	
Sphagnum spp.	II				I				V	V	II
Cladina stellaris											I
Number of plots	156	77	196	155	165	110	135	21	12	29	51
Mean number of species/plot	13.7	5.6	7.7	6.9	9.8	9.5	6.5	4.0	13.9	8.9	8.9
Standard error (±)	0.44	0.34	0.23	0.20	0.29	0.27	0.29	0.44	2.2	0.60	0.38
Scheffe test[1]	a	abcdeg	abcdg	abcd	ab	ac	abcd	abcdefg	d	af	ag

[1] One-way ANOVA (df = 10) F = 53.0, p<0.001. Means with the same letter are significantly different from a mean with an underlined letter. 'a' is significantly different from 'a' (Scheffe multiple comparison test, p<0.05).

2 Frequency classes:
• = <10%;
I = 10-19%;
II = 20-39%;
III = 40-59%;
IV = 60-79%;

TABLE 3-3. The percentage frequency of the tree species associated with the ground flora TWINSPAN groups. (Trees, defined as ≥ 9 cm dbh, were recorded in the variable-radius plots - which included the area of the ground flora plots.) Only species with a frequency ≥ 5% in at least one TWINSPAN group have been included, and for those species listed only values ≥ 5% are given - the presence of a species at a frequency of < 5% is represented by a dot (•). Frequencies printed in bold were significantly greater (χ^2 test, p<0.01) than the frequency for the same species in all 1200 plots).

SPECIES	GROUND FLORA TWINSPAN GROUP											ALL
	3	5	6	7	8	9	10	11	12	13	14	1200 PLOTS
Conifers:												
Abies balsamea	66	74	71	68	**78**	71	29	62	58	34	29	59.8
Larix laricina	**24**		5	•	10	17	19	10	**50**	**48**	22	12.3
Picea glauca	53	25	45	26	50	55	**85**	52	17	10	22	45.6
Picea mariana	15		•		18	**27**	6		**83**	**76**	**61**	13.8
Picea rubens	•	5	6	•	19	**26**	17	**24**	17	17	**31**	12.0
Pinus strobus			•	•	•	**6**	•			•	•	1.4
Thuja occidentalis	**14**		•		•	•			**8**	•		2.8
Tsuga canadensis		**6**	•	•	•	•	•	•				1.8
Broad-leaved species:												
Acer rubrum	58	**87**	**69**	**80**	60	46	16	29	75	14	14	52.1
Acer pensylvanicum		**5**	•	•	•							1.2
Acer saccharum	8	**48**	**27**	**42**	•	•	•					15.0
Betula alleghaniensis	18	**47**	**26**	**28**	13	•	•	33				16.3
Betula papyrifera	35	25	**47**	**47**	30	18	25	57	8	7	•	30.8
Betula populifolia	•	•	•	•	7	7	6				10	3.9
Fagus grandifolia		17	**18**	**21**	5	•	•	**24**				8.6
Populus grandidentata			5	•	•	•	•	•			•	2.5
Populus tremuloides	22	•	16	19	25	**30**	20	33			6	18.2
Prunus pensylvanica	•	10	10	8	8	•	5	10				6.0
Ulmus americana	**11**	•	•									1.8
Number of plots	156	77	196	155	165	118	135	21	12	29	51	1200
Mean number of species/plot*	3.4^{abc}	3.6^{abc}	3.6^{abc}	3.6^{abc}	3.4^{abc}	3.2^{ac}	$2.4^{\underline{c}}$	3.4	3.2	$2.2^{\underline{b}}$	$2.0^{\underline{a}}$	3.2
Standard error (±)	0.12	0.16	0.09	0.10	0.10	0.11	0.11	0.30	0.37	0.20	0.16	0.04

* One-way ANOVA, (df = 10) F = 16.2, p < 0.0001. Means with the same superscript are significantly different from a mean with in underlined superscript, ^{a} is significantly different from $\underline{a}$ (Scheffe multiple comparison test, p < 0.05).

TABLE 3-4. Frequency classes of the tree species associated with the ground flora TWINSPAN groups. (Trees, defined as ≥ 9 cm dbh, were recorded in the variable-radius plots - which included the area of the ground flora plots.) Only species with a frequency of ≥ 5% in at least one TWINSPAN group have been included. Frequencies printed in bold were significantly greater (χ^2 test, $p<0.01$) than the frequency for the same species in all 1200 plots. (See the footnote for the frequency class sizes.)

SPECIES	GROUND FLORA TWINSPAN GROUP										
	3	5	6	7	8	9	10	11	12	13	14
Conifers:											
Abies balsamea	IV	IV	IV	IV	**IV**	IV	II	IV	III	II	II
Larix laricina	**II**		I		I	I	I	I	**III**	**III**	II
Picea glauca	III	II	III	II	III	III	**V**	III	I	I	II
Picea mariana	I				I	**II**	I		**V**	**IV**	**IV**
Picea rubens		I	I		I	**II**	I	II	I	I	**II**
Pinus strobus						**I**					
Thuja occidentalis	**I**								I		
Tsuga canadensis		**I**									
Broad-leaved species:											
Acer rubrum	III	**V**	**IV**	**V**	IV	III	I	II	IV	I	I
Acer pensylvanicum		**I**									
Acer saccharum	I	**III**	**II**	**III**							
Betula alleghaniensis	I	**III**	**II**	**II**	I			II			
Betula papyrifera	II	II	**III**	**III**	II	I	II	III	I	I	
Betula populifolia					I	I	I				I
Fagus grandifolia		I	**I**	**II**	I			II			
Populus grandidentata			I								
Populus tremuloides	II		I	I	II	**II**	II	II			I
Prunus pensylvanica		I	I	I	I		I	I			
Ulmus americana	**I**										
Number of plots	156	77	196	155	165	118	135	21	12	29	51

Frequency classes:
I = (05 - 19)%
II = (20 - 39)%
III = (40 - 59)%
IV = (60 - 79)%
V = ≥ 80%

TABLE 3-5. The mean of the percentage contribution of each tree species to the total tree biomass in the variable-radius plots associated with the ground flora TWINSPAN groups. With the exception of *Acer pensylvanicum*, tree species not having a value of ≥1% in at least one TWINSPAN group have been omitted. (Standard errors are bracketed; the letters in each box refer to Scheffe multiple comparison tests - see footnote).

SPECIES	GROUND FLORA TWINSPAN GROUP											ONE-WAY ANOVA*		
	3	5	6	7	8	9	10	11	12	13	14	F	p	p level
CONIFERS:														
Abies balsamea	13.5 (1.5) a	10.8 (2.7)	10.9 (1.9)	19.0 (2.0)	26.9 (2.2) a	22.1 (2.3) b	8.4 (1.7) ab	24.3 (6.3)	17.5 (5.7)	6.2 (3.2)	7.3 (2.5) a	7.23	0.0000	***
Larix laricina	7.3 (1.7) b	0 ab	0.99 (0.39) ab	0.06 (0.06) ab	3.0 (0.79) a	5.0 (1.2)	3.7 (0.85) a	0.95 (0.66)	9.2 (5.8)	15.2 (3.9) a	5.5 (2.4)	7.99	0.0000	***
Picea glauca	18.0 (2.2) ac	3.1 (0.79) a	13.4 (1.7) a	5.2 (1.1) abc	15.3 (1.9) a	18.6 (2.5) ab	62.2 (3.4) a	21.4 (6.7) a	1.7 (1.1) a	4.1 (3.5) a	9.0 (3.0) a	51.02	0.0000	***
Picea mariana	3.8 (1.2) ab	0 abc	1.6 (0.75) abc	0 abc	7.6 (1.6) ab	13.7 (2.6) abc	4.3 (1.5) ab	0 ab	16.7 (4.3) ab	56.9 (7.4) a	51.0 (6.5) b	52.49	0.0000	***
Picea rubens	0.51 (0.30) ab	0.65 (0.34) ab	1.2 (0.51) ab	0.58 (0.33) ab	4.2 (1.1) a	11.1 (2.3) b	4.6 (1.2) a	8.3 (1.9)	13.3 (9.3)	11.7 (5.7)	20.4 (4.9) a	12.70	0.0000	***
Pinus strobus			0.05 (0.05)		0.30 (0.20)	1.7 (0.93)	0.4 (0.4)			0.17 (0.17)	0.20 (0.20)	2.26	0.012	*
Thuja occidentalis	7.1 (1.7) a	0 a	0.92 (0.54) a	0 a	0.79 (0.45) a	0.42 (0.42) a	0 a		6.7 (6.7)	0.34 (0.34)	0 a	7.39	0.0000	***
Tsuga canadensis		1.1 (0.80)	0.18 (0.12)	0.10 (0.07)	0.55 (0.39)	0.25 (0.25)	0.81 (0.54)	2.4 (2.4)				1.38	0.180	ns
TOTAL CONIFERS	50.2	23.6	37.4	25.0	58.6	72.8	84.1	53.4	65.0	96.4	93.3			
BROAD LEAVES:														
Acer rubrum	24.6 (2.4) bd	39.6 (3.4) a	27.6 (2.0) c	37.5 (2.5) b	22.6 (2.1) abe	13.9 (2.0) abc	4.6 (1.1) abcde	7.4 (3.4) ab	31.7 (7.9)	3.1 (1.5) abc	2.2 (0.85) abcde	23.44	0.0000	***
Acer pensylvanicum		0.19 (0.14)	0.38 (0.20)	0.13 (0.09)	0.06 (0.06)							1.26	0.247	ns

SPECIES	GROUND FLORA TWINSPAN GROUP											ONE-WAY ANOVA[*]		
	3	5	6	7	8	9	10	11	12	13	14	F	p	p level
Acer saccharum	1.7 (0.56) ab	17.8 (3.1) a	6.5 (1.0) ac	9.8 (1.4) ab	0.24 (0.12) abc	0.34 (0.27) abc	0.59 (0.46) abc	0 a	0 a	0 a	0 ab	21.40	0.0000	***
Betula alleghaniesis	3.3 (0.84) a	10.6 (2.1) a	4.8 (0.86) ab	4.2 (0.74) a	2.3 (0.67) a	0.08 (0.08) a	0.22 (0.13) ab	5.0 (1.9)		0 a	0 a	9.36	0.0000	***
Betula papyrifera	5.6 (0.94)	3.6 (0.92) a	9.9 (1.1) b	11.1 (1.4) a	5.3 (0.90)	2.5 (0.66) ab	3.6 (0.78) ab	13.8 (4.9)	0.83 (0.83)	0.86 (0.70)	0.49 (0.40) ab	9.03	0.0000	***
Betula populifolia	0.45 (0.25)		0.10 (0.10)	0.52 (0.30)	0.42 (0.15)	0.17 (0.12)	0.59 (0.27)				1.2 (0.60)	1.28	0.233	ns
Fagus grandifolia	0 abc	2.7 (0.93) a	3.9 (0.85) ac	5.2 (1.1) b	0.27 (0.15) ab	0.17 (0.17) ab	0.37 (0.24) ab	13.3 (5.9) a	0 a	0 a	0 a	10.33	0.0000	***
Fraxinus americana	1.6 (0.56)	0.65 (0.47)	0.61 (0.43)									1.74	0.67	ns
Populus grandidentata			1.4 (0.59)	1.2 (0.66)	1.0 (0.71)	0.93 (0.43)	0.74 (0.43)	0.48 (0.48)			0.39 (0.39)	0.767	0.660	ns
Populus tremuloides	7.2 (1.5)	0.13 (0.13)	5.2 (1.1)	4.7 (1.2)	7.2 (1.4)	7.6 (1.7)	4.7 (1.2)	7.9 (2.7)			1.8 (1.6)	2.54	0.0048	**
Prunus pensylvanica	1.6 (0.82)	0.65 (0.32)	2.2 (0.75)	0.77 (0.30)	1.8 (0.79)	0.42 (0.30)	1.2 (0.64)	0.71 (0.52)				0.931	0.503	ns
Ulmus americana	3.2 (1.0) a	1.0 (0.73)	0.15 (0.11) a	0 a	0 a	0 a	0 a					5.14	0.0000	***
TOTAL BROAD-LEAVED	50.2	77.4	62.9	75.2	41.2	26.3	16.5	48.6	32.5	4.0	6.0			
Number of plots	156	77	196	155	165	118	135	21	12	29	51			

[*] One-way ANOVA (df = 10). Means with the same letter are significantly different from a mean with an underlined letter, 'a' is significantly different from 'a' (Scheffe multiple comparison test, $p < 0.05$).

p level = probability level:
- * ($p < 0.05$)
- ** ($p < 0.01$)
- *** ($p < 0.001$)
- n.s. not significant

TABLE 3-6 Class table for the mean percentage contribution of the different tree species to the total tree biomass in the ground flora TWINSPAN groups. (Several rarer broad-leaved species omitted from Table 3-3 have been included here.) (See the footnote for the class sizes.)

SPECIES	GROUND FLORA TWINSPAN GROUP										
	3	5	6	7	8	9	10	11	12	13	14
CONIFERS:											
Abies balsamea	II	II	II	II	III	III	I	III	II	I	I
Larix laricina	I		•	•	•	I	•	•	I	II	I
Picea glauca	II	•	II	I	II	II	V	III	•	•	I
Picea mariana	•		•		I	II	•		II	V	V
Picea rubens	•	•	•	•	•	II	•	•	II	II	III
Pinus strobus			•		•	•	•			•	•
Thuja occidentalis	I		•		•	•			I	•	
Tsuga canadensis		•	•	•	•	•	•				
BROAD LEAVES:											
Acer rubrum	III	IV	III	IV	III	II	•	I	IV	•	•
Acer pensylvanicum		•	•	•	•						
Acer saccharum	•	II	I	I	•	•	•				
Betula alleghaniesis	•	II	•	•	•	•	•	I			
Betula papyrifera	I	•	I	II	I	•	•	II	•	•	•
Betula populifolia	•		•	•	•	•	•				•
Fagus grandifolia		•	•	I	•	•	•	II			
Fraxinus americana	•	•	•								
Populus grandidentata			•	•	•	•	•	•			•
Populus tremuloides	I	•	I	•	I	I	•	I			•
Prunus pensylvanica	•	•	•	•	•	•	•	•			
Ulmus americana	•	•	•								
RARER BROAD LEAVES:											
Acer spicatum		•									
Amelanchier spp.			•		•						
Fraxinus nigra	•										
Quercus rubra			•	•							
Salix spp.	•										
Sorbus americana			•								
Number of plots	156	77	196	155	165	118	135	21	12	29	51

Class sizes:

•	< 5%
I	5 - < 10%
II	10 - < 20%
III	20 - < 30%
IV	30 - < 40%
V	≥ 50%

TABLE 3-7. The mean height, age and 'actual density' of the trees for each ground flora TWINSPAN group. Height and age measurements were made on two trees at each sampling point (usually the largest conifer and broad-leaf - if both occurred). See the Methods for the definition of actual density. (Standard errors are bracketed; the letters refer to Scheffe multiple comparison tests - see footnote).

	GROUND FLORA TWINSPAN GROUP											ONE-WAY ANOVA*		
	3	5	6	7	8	9	10	11	12	13	14	F	p	p level
Mean height of trees (m)	14.5^{abcd} (0.17)	$16.3^{ab\underline{c}}$ (0.23)	$15.6^{ab\underline{d}}$ (0.13)	15.2^{abc} (0.13)	15.0^{abc} (0.14)	14.3^{abcd} (0.17)	14.9^{abc} (0.14)	15.3^{ab} (0.40)	13.5^{c} (0.55)	$11.9^{\underline{a}}$ (0.33)	$12.6^{\underline{b}}$ (0.24)	27.12	0.0000	***
Mean age of trees (yr)	60.4^{ac} (1.2)	$66.9^{a\underline{b}}$ (1.5)	57.3^{ab} (0.86)	57.2^{ab} (0.90)	56.0^{ab} (0.91)	$53.5^{ab\underline{c}}$ (1.1)	$44.2^{\underline{a}}$ (0.88)	53.2^{b} (2.5)	68.4^{a} (5.3)	53.6^{b} (3.3)	57.0^{ab} (2.0)	21.53	0.0000	***
Mean of 'actual density' (%)	$68.6^{\underline{c}}$ (3.2)	90.6^{abc} (3.6)	81.9^{a} (2.6)	89.0^{abc} (2.8)	75.1^{a} (2.5)	$66.9^{\underline{b}}$ (3.0)	83.4^{a} (3.0)	88.7^{a} (6.9)	50.0 (9.5)	60.6 (7.4)	$47.7^{\underline{a}}$ (4.1)	11.11	0.0000	***

* One-way ANOVA (df = 10). Means with the same superscript are significantly different from a mean with an underlined superscript, 'a' is significantly different from '$\underline{a}$' (Scheffe multiple comparison test, $p < 0.05$)

p level = probability level:
* ($p < 0.05$)
** ($p < 0.01$)
*** ($p < 0.001$)
n.s. not significant

TABLE 3-8. The species percentage frequency of the **shrubs and small trees** associated with the ground flora TWINSPAN groups. (Shrubs/small trees are defined as ≥ 1.3m in height but < 9cm in dbh). Only species with a frequency ≥ 1% in at least one TWINSPAN group have been listed, and for these species, frequencies of < 2% are indicated by a dot(•). Frequencies in bold were significantly greater (χ^2 test, $p < 0.01$) than the frequencies for the same species in all 1200 Inventory plots.

SPECIES	GROUND FLORA TWINSPAN GROUP											ALL
	3	5	6	7	8	9	10	11	12	13	14	1200 PLOTS
Conifers:												
Abies balsamea	40	**44**	**58**	**56**	**67**	**58**	22	57	50	31	29	40.9
Larix laricina	6		•		•	4	3		8	**24**	4	2.8
Picea glauca	12	5	12	10	15	19	**59**	**38**	8	7	14	12.8
Picea mariana	2				4	10	2		**33**	**62**	**53**	5.9
Picea rubens	•	•	•	2	6	**14**	4	5	8	7	**20**	3.5
Thuja occidentalis	**10**		2		•				8			1.7
Taxus canadensis	**5**	3	2	•	•							1.4
Broad-leaved species:												
Acer rubrum	23	**42**	**35**	**39**	30	29	8	19	17	7	16	24.8
Acer pensylvanicum	•	**8**	**5**	•	•							1.6
Acer saccharum	3	**19**	12	**26**	•		•	5				7.2
Betula alleghaniensis	4	**14**	**9**	7	4	•	•					4.5
Betula papyrifera	12	4	**16**	7	10	15	8	**29**	8	7		9.0
Betula populifolia	3		•		•	**8**	4		**8**	10	4	2.9
Fagus grandifolia		3	5	**10**	•			**14**				2.4
Fraxinus americana	3	•	3	•								1.1
Fraxinus nigra	**3**											0.25
Populus grandidentata						•	•					0.25
Populus tremuloides	**13**		4	•	8	**12**	7	14	8		•	5.4
Prunus pensylvanica	8	3	11	4	10	**15**	10	14	8		•	7.2
Sorbus americana	6	•	8	•	5	3	•			3	•	3.9
Broad-leaved species normally of shrub size:												
Acer spicatum	**15**	**17**	**6**	3								4.3
Alnus rugosa	**24**		•	•	4	3	7	5	25	7	4	6.2
Amelanchier spp.	•		•			3	•			3	4	0.9
Cornus alternifolia	•		•									0.33
Cornus stolonifera	•											0.25
Corylus cornuta	**7**		3	3		•						2.1
Ilex verticillata	**6**	•	•		•				**17**	3		1.7
Nemopanthus mucronata	•		•		2	**6**			17	**21**	•	2.0
Prunus virginiana	•											0.17
Salix spp.	**10**			•	•	•	•			3	4	2.6
Sambucus pubens	•	•	2	•	•							0.92
Viburnum cassinoides	**8**	•	•	•	13	**33**	•			**34**	**28**	7.4
Number of plots	156	77	196	155	165	118	135	21	12	29	51	1200
Mean number of species/plot*	2.3^{a}	1.7	2.0	1.8	1.9	2.3^{a}	$1.4^{\underline{a}}$	2.0	2.3	2.3	1.9	2.0
Standard error (±)	(0.11)	(0.13)	(0.09)	(0.09)	(0.09)	(0.13)	(0.08)	(0.26)	(0.28)	(0.21)	(0.17)	(0.06)

* One-way ANOVA, (df = 10) $F = 5.66$, $p < 0.0001$. Means with the same superscript are significantly different from a mean with an underlined superscript, ^{a} is significantly different from $^{\underline{a}}$ (Scheffe multiple comparison test, $p < 0.05$).

TABLE 3-10. The species percentage frequency of the **regeneration trees** associated with the ground flora TWINSPAN groups. Only species with a frequency ≥ 1% in at least one TWINSPAN group have been listed - excluding species that attain this level due to a single occurrence in the smallest groups (11 and 12). For the species listed, frequencies of < 2% are indicated by a dot(•). Frequencies in bold were significantly greater (χ^2 test, $p < 0.01$) than the frequency for the same species in all 1200 Inventory plots. (Regeneration trees are defined as ≥ 15cm but < 1.3m in height).

SPECIES	GROUND FLORA TWINSPAN GROUP											ALL
	3	5	6	7	8	9	10	11	12	13	14	1200 PLOTS
Conifers:												
Abies balsamea	14	26	**38**	**43**	**45**	31	17	38	33	10	18	29.8
Larix laricina	•					•	•		**17**	3	•	0.92
Picea glauca	4	•	3	3	4	6	9	10			4	4.3
Picea mariana	•		•		2	4	3			**28**	**27**	3.8
Picea rubens			•	•	•	**8**	2			3	**14**	2.0
Thuja occidentalis	3				•				**8**			0.58
Broad-leaved species:												
Acer rubrum	17	18	32	17	32	35	17	5	**67**	28	25	24.3
Acer pensylvanicum	•	**17**	**13**	**17**	5		•					6.4
Acer spicatum	4	4	3	•	•							1.5
Acer saccharum	3	**17**	**14**	**19**	•		•	5				6.0
Alnus rugosa	•					•			**8**		•	0.75
Betula alleghaniensis	3	5	7	5	2		•					3.0
Betula papyrifera	9	3	7	•	8	**8**	7	5		14	6	6.9
Betula populifolia				•	2	•	3		**8**	3		1.3
Fagus grandifolia		•	4	**6**	•	•	•	5				2.0
Fraxinus americana	**3**	•	•	•								0.58
Populus grandidentata			2	•	•		•					0.58
Populus tremuloides	•	•	8	4	9	5	9	**29**	**8**		•	5.4
Prunus pensylvanica	•	3	2	•	2	3	2					2.7
Salix spp.	•				•						•	0.50
Sorbus americana							•					0.17
Viburnum cassinoides											•	0.17
Number of plots	156	77	196	155	165	118	135	21	12	29	51	1200
Mean number of species/plot*	$0.69^{\underline{a}}$	0.97	1.4^{ab}	1.2	1.2^{a}	1.1	$0.77^{\underline{b}}$	1.0	1.5	0.90	1.1	1.6
Standard error (±)	0.075	0.11	0.084	0.084	0.087	0.081	0.082	0.20	0.29	0.20	0.12	0.03

* One-way ANOVA. (df = 10) F = 5.51, $p < 0.0001$. Means with the same superscript are significantly different from a mean with an underlined superscript., ^{a} is significantly different from $^{\underline{a}}$ (Scheffe multiple comparison test, $p < 0.05$).

TABLE 3-9. The mean number of shrubs and small trees (per 16m² plot - excluding plots with zero counts) associated with the ground flor TWINSPAN groups. Only species with a frequency ≥ 1% in at least one TWINSPAN group have been listed. (Shrubs and small trees are defined as ≥ 1.3m in height but < 9cm dbh. Standard errors are in brackets.)

SPECIES	GROUND FLORA TWINSPAN GROUP										
	3	5	6	7	8	9	10	11	12	13	14
Conifers:											
Abies balsamea	2.4 (0.33)	6.2 (1.2)	4.2 (0.44)	5.0 (0.49)	5.9 (0.71)	4.7 (0.64)	6.4 (1.1)	5.4 (1.4)	1.8 (0.54)	6.2 (2.7)	3.5 (1.1)
Larix laricina	5.5 (2.7)		4.0 (3.0)		1 (0)	2.0 (0.77)	1 (0)		1 (0)	2.0 (0.85)	1.5 (0.50)
Picea glauca	1.9 (0.33)	1 (0)	3.5 (0.89)	2.6 (0.88)	3.0 (0.46)	3.1 (0.90)	6.7 (1.1)	4.8 (0.82)	1 (0)	1.5 (0.50)	3.4 (0.90)
Picea mariana	8.0 (5.0)				1.3 (0.18)	2.6 (0.60)	7.0 (5.0)		2.5 (1.5)	4.4 (0.75)	6.7 (1.1)
Picea rubens	3 (0)	3 (0)	4.0 (3.0)	1.7 (0.67)	1.1 (0.10)	4.6 (1.5)	2.0 (0.55)	1 (0)	5 (0)	6.0 (2.0)	3.3 (0.90)
Thuja occidentalis	3.8 (1.0)		2.3 (0.63)		8.0 (7.0)				1 (0)		
Taxus canadensis	2.7 (1.2)	5.5 (2.5)	7.3 (4.6)	2.0 (0)	1.0 (0)						
Broad-leaved species:											
Acer rubrum	3.2 (0.56)	2.2 (0.30)	3.9 (0.45)	3.1 (0.40)	3.9 (0.59)	4.0 (0.75)	3.1 (0.62)	5.0 (0.8)	3.5 (0.5)	1.0	2.0 (0.38)
Acer pensylvanicum	1 (0)	1.8 (0.48)	2.8 (0.7)	3.0 (2.0)	2 (0)						
Acer saccharum	3.3 (2.3)	2.0 (0.24)	3.5 (0.73)	2.9 (0.32)	2.3 (0.33)		1 (0)	4 (0)			
Betula alleghaniensis	2.3 (0.71)	2.0 (0.50)	1.5 (0.23)	1.5 (0.28)	2.7 (0.52)	1 (0)	5 (0)				
Betula papyrifera	1.4 (0.18)	1.7 (0.67)	2.0 (0.37)	2.3 (0.56)	2.0 (0.53)	2.1 (0.67)	2.2 (0.54)	1 (0)	1 (0)	2.5 (1.5)	
Betula populifolia	1.5 (0.50)		1 (0)		3.0 (1.1)	2.3 (1.1)	1.4 (0.24)		8 (0)	2.0 (0.58)	2.0 (1.0)
Fagus grandifolia		4.0 (3.0)	2.0 (0.45)	2.4 (0.54)	1 (0)			1.3 (0.33)			
Fraxinus americana	1.2 (0.20)	2 (0)	3.5 (1.3)	1 (0)							
Fraxinus nigra	2.0 (1.0)										
Populus grandidentata						2.5 (1.5)	3 (0)				
Populus tremuloides	3.8 (1.6)		2.3 (0.56)	1.5 (0.50)	1.6 (0.29)	2.8 (1.5)	4.5 (1.8)	2.0 (1.0)	10 (0)		1 (0)

SPECIES	GROUND FLORA TWINSPAN GROUP										
	3	5	6	7	8	9	10	11	12	13	14
Prunus pensylvanica	3.5 (0.75)	4.5 (1.5)	2.2 (0.36)	1.3 (0.21)	2.9 (0.44)	2.6 (0.52)	1.6 (0.20)	1.3 (0.33)	1 (0)		2 (0)
Sorbus americana	3.3 (0.96)	1 (0)	3.5 (0.95)	1 (0)	4.9 (3.1)	4.0 (2.4)	2.0 (1.0)			2 (0)	1 (0)
Broad-leaved species normally of shrub size:											
Alnus rugosa	11.2 (1.8)		10.0 (6.0)	2 (0)	4.3 (2.2)	6.3 (4.3)	10.6 (4.2)	11 (0)	9.7 (0.88)	2.0 (0)	1.5 (0.50)
Acer spicatum	7.9 (1.5)	3.2 (0.66)	5.3 (1.6)	2.0 (0.41)							
Amelanchier spp.	3 (0)		1 (0)			1.7 (0.33)	3.0 (1.0)			1 (0)	1.5 (0.50)
Cornus alternifolia	7 (0)		1 (0)								
Cornus stolonifera	5.0 (2.0)										
Corylus cornuta	7.6 (1.5)		6.2 (2.4)	6.0 (2.9)		1 (0)					
Ilex verticillata	8.6 (2.4)	1 (0)	1 (0)		1.5 (0.5)				13.0 (7.0)	1 (0)	2 (0)
Nemopanthus mucronata	4.0 (1.0)		5.5 (0.50)		5.3 (2.3)	10.3 (6.1)			7.0 (1.0)	6.5 (1.6)	10 (0)
Prunus virginiana	1.5 (0.50)										
Salix spp.	3.6 (0.64)			29 (0)	9 (0)	3.0 (2.0)	2.5 (0.50)			1 (0)	1.5 (0.50)
Sambucus pubens	4.0 (3.0)	1 (0)	4.0 (0.71)	1 (0)	4 (0)						
Viburnum cassinoides	4.8 (0.97)	1 (0)	1 (0)	1 (0)	4.5 (0.91)	5.7 (1.0)	6.5 (2.5)			4.8 (0.89)	8.8 (1.9)
All species combined (for all plots including zero counts)*	$10.4^{\underline{a}}$ (0.79)	5.8 (0.69)	7.1 (0.50)	6.3^{a} (0.51)	8.0 (0.69)	9.1 (0.85)	7.7 (0.81)	7.6 (1.5)	10.5 (2.8)	9.5 (1.3)	8.9 (1.1)
Number of plots	156	77	196	155	165	118	135	21	12	29	51

* One-way ANOVA, (df = 10) F = 3.27, $p < 0.001$. Means with the same superscript are significantly different from a mean with underlined superscript, ^{a} is significantly different from $^{\underline{a}}$ (Scheffe multiple comparison test, $p < 0.05$).

TABLE 3-11. The mean number of **regeneration trees** (per $4m^2$ plot - excluding plots with zero counts) associated with the ground flora TWINSPAN groups. Only species with a frequency ≥ 1% in at least one TWINSPAN group have been listed - excluding species that attain this level due to a single occurrence in the smallest groups (11 and 12). (Regeneration trees are defined as ≥ 15cm but < 1.3m in height. Standard errors are in brackets.)

SPECIES	GROUND FLORA TWINSPAN GROUP										
	3	5	6	7	8	9	10	11	12	13	14
Conifers:											
Abies balsamea	2.2 (0.38)	3.4 (0.80)	3.7 (0.40)	3.3 (0.37)	4.2 (0.63)	3.5 (0.61)	3.8 (0.73)	3.2 (0.99)	2.8 (0.48)	4.0 (1.2)	2.1 (0.54)
Larix laricina	2.5 (1.5)					1.5 (0.5)	1.0 (0)		3.0 (2.0)	1.0 (0)	1.0 (0)
Picea glauca	1.8 (0.40)	1.0 (0)	1.2 (0.20)	1.3 (0.25)	4.2 (1.9)	1.6 (0.43)	5.6 (1.7)	1.0 (0)			1.5 (0.50)
Picea mariana	1.0 (0)		4.0 (0)		2.8 (1.2)	4.6 (1.5)	1.5 (0.50)			5.6 (2.4)	2.1 (0.54)
Picea rubens			1.0 (0)	1.0 (0)	1.0 (0)	3.8 (2.1)	2.0 (1.0)			1.0 (0)	3.6 (1.3)
Thuja occidentalis	22.0 (19.3)				1.5 (0.50)				4.0 (0)		
Broad-leaved species:											
Acer rubrum	3.5 (0.56)	2.1 (0.45)	5.7 (1.0)	5.4 (2.5)	6.8 (1.1)	4.2 (0.66)	5.6 (1.4)	1.0 (0)	1.5 (0.33)	4.8 (1.4)	4.4 (1.5)
Acer pensylvanicum	3.0 (1.0)	1.8 (0.32)	4.0 (1.1)	5.4 (0.98)	2.5 (0.60)		1.0 (0)				
Acer spicatum	9.8 (2.0)	0.67 (0.33)	6.0 (2.9)	1.0 (0)	1.0 (0)						
Acer saccharum	4.0 (3.0)	5.9 (3.0)	6.3 (1.6)	4.7 (1.2)	1.0 (0)		1.0 (0)	5.0 (0)			
Alnus rugosa	2.0 (0.58)				2.0 (0)				2.0 (0)		

SPECIES	GROUND FLORA TWINSPAN GROUP										
	3	5	6	7	8	9	10	11	12	13	14
Betula alleghaniensis	2.6 (1.4)	2.5 (0.65)	2.6 (0.66)	3.3 (1.1)	4.0 (2.4)		1.0 (0)				
Betula papyrifera	1.5 (0.17)	1.5 (0.50)	3.5 (1.1)	1.0 (0)	4.9 (1.2)	1.6 (0.24)	2.2 (0.61)	2.0 (0)		1.8 (0.48)	2.0 (0.58)
Betula populifolia				10.0 (0)	5.0 (1.1)	1.5 (0.50)	6.8 (2.5)		1.0 (0)	4.0 (0)	
Fagus grandifolia		2.0 (0)	1.5 (0.27)	2.2 (0.63)	1.5 (0.50)	2.0 (0)	1.0 (0)	35.0 (0)			
Fraxinus americana	1.3 (0.25)	2.0 (0)	3.0 (0)	1.0 (0)							
Populus grandidentata			1.5 (0.50)	3.0 (0)	1.0 (0)		1.0 (0)				
Populus tremuloides	2.0 (0)	1.0 (0)	2.9 (0.57)	4.0 (1.2)	3.0 (0.49)	1.8 (0.48)	2.3 (0.30)	3.2 (0.95)	2.0 (0)		3.0 (0)
Prunus pensylvanica	1.0 (0)	1.0 (0)	1.3 (0.25)	3.0 (2.0)	1.0 (0)	1.3 (0.33)	1.0 (0)				
Salix spp.	8.7 (3.5)				1.0 (0)						12.0 (0)
Sorbus americana							2.0 (1.0)				
Viburnum cassinoides											1.0 (0)
All species combined (for all plots including zero counts)*	2.6 (0.58)	2.8 (0.62)	5.7 (0.62)	4.6 (0.64)	5.4 (0.69)	3.5 (0.44)	2.9 (0.44)	4.3 (1.9)	3.2 (0.74)	3.7 (1.1)	4.4 (0.79)
Number of plots	156	77	196	155	165	118	135	21	12	29	51

* One-way ANOVA, (df = 10) F = 2.89, $p < 0.0014$. No two groups were significantly different at the .050 level) (Scheffe multiple comparison test, $p < 0.05$).

TABLE 3-12. General stand and site attributes for the ground flora TWINSPAN groups. For each group the percentage of plots in each clas is given. Those percentages printed in bold have made a greater contribution to the χ^2 value than those in plain text - se footnote 1.

ATTRIBUTE	CLASS	GROUND FLORA TWINSPAN GROUP											ALL PLOTS	χ^2 TEST OF ASSOCIATION[1]			
		3	5	6	7	8	9	10	11	12	13	14		χ^2: Row sums	TOTAL χ^2	df	p level
Geographical region	West	**55.1**$^+$	15.6	24.0	**14.2**$^-$	24.8	31.4	**12.6**$^-$	9.5	16.7	37.9	23.5	25.9	**77.9**	234.7	20	***
	Central	**17.9**$^-$	**48.1**$^+$	**54.6**$^+$	**52.9**$^+$	**21.8**$^-$	**14.4**$^-$	28.1	33.3	16.7	27.6	**7.8**$^-$	32.8	**93.3**			
	East	**26.9**$^-$	36.4	**21.4**$^-$	32.9	**53.3**$^+$	**54.2**$^+$	**59.3**$^+$	57.1	66.7	34.5	**68.6**$^+$	41.3	**63.4**			
	χ^2: Group sums	**69.6**	9.0	**47.2**	**29.0**	**11.9**	**18.3**	**20.7**	3.4	3.2	2.1	**19.0**					
Forest type	HH (>75% hardwood)	29.5	**76.6**$^+$	**50.5**$^+$	**67.7**$^+$	**18.2**$^-$	**11.0**	**11.1**	**61.9**$^+$	33.3	**6.9**	**3.9**	34.8	**180.9**	563.8	40	***
	HS (51-75% hardwood)	32.1	**14.3**$^-$	29.6	24.5	**40.6**$^+$	29.7	**15.6**$^-$	23.8	8.3	**6.9**$^-$	**2.0**$^-$	25.9	**44.1**			
	SH (51-75% softwood)	25.6	**7.8**$^-$	**14.3**$^-$	**3.9**$^-$	**27.9**$^+$	**40.7**$^+$	27.4	14.3	25.0	10.3	25.5	20.9	**64.8**			
	SS (>75% softwood)	**9.0**$^-$	**0**$^-$	**5.1**	**2.6**$^-$	12.1	17.8	**45.2**$^+$	0	33.3	**75.9**$^+$	**68.6**$^+$	17.1	**262.7**			
	Other	**3.8**$^+$	1.3	0.5	1.2	1.2	0.8	0.7	0	0	0	0	1.2	11.1			
	χ^2: Group sums	**19.6**	**62.2**	**36.4**	**89.1**	**33.0**	**42.3**	**92.3**	**8.7**	3.5	**70.9**	**105.4**					
Stand age	Regeneration	1.3	0	2.0	0.6	0.6	0.8	1.5	0	0	0	0	0.98	4.9	151.4	40	***
	Immature	**19.2**$^-$	23.4	26.0	36.8	26.1	26.3	**43.0**$^+$	28.6	8.3	34.5	27.5	28.6	21.9			
	Mature	30.1	36.4	38.8	**28.4**$^-$	46.7	33.9	40.0	47.6	58.3	58.6	49.0	38.1	16.9			
	Over-mature	**14.1**$^+$	1.3	2.6	0.6	1.8	0	**0**$^-$	0	**16.7**$^+$	0	2.0	3.1	**81.5**			
	Uneven-aged	35.3	39.0	30.6	33.5	24.8	**39.0**$^+$	**15.6**$^-$	23.8	16.7	**6.9**$^-$	21.6	29.1	**25.9**			
	χ^2: Group sums	**69.3**	4.9	3.0	11.7	5.7	8.3	**22.9**	1.5	10.7	9.6	3.3					
Stocking class	1 (0-25%)	**5.1**$^+$	0	0.5	0	1.2	0	0	0	0	0	0	0.99	33.7	229.5	30	***
	2 (26-50%)	**23.1**$^+$	**0**$^-$	**4.1**$^-$	**1.3**$^-$	5.5	12.7	7.4	0	25.0	**20.7**$^+$	**17.6**$^+$	8.8	**76.9**			
	3 (51-75%)	**40.4**$^+$	**6.5**$^-$	25.5	**18.1**$^-$	26.7	**39.8**$^+$	20.0	9.5	50.0	**48.3**$^+$	**45.1**$^+$	27.7	**50.9**			
	4 (76-100%)	**31.4**$^-$	**93.5**$^+$	69.9	**80.6**$^+$	66.7	**47.5**	72.6	90.5	25.0	**31.0**	37.3	62.5	**67.8**			
	χ^2: Group sums	**96.7**	**31.8**	7.4	**26.7**	2.6	**13.7**	6.7	7.1	8.5	**14.0**	**15.8**					

ATTRIBUTE	CLASS	GROUND FLORA TWINSPAN GROUP											ALL PLOTS	χ^2 TEST OF ASSOCIATION[1]			
		3	5	6	7	8	9	10	11	12	13	14		χ^2: Row sums	TOTAL χ^2	df	p level
Stand origin/history	Old field	17.9	**6.5**$^{-}$	16.3	**1.9**$^{-}$	17.0	13.6	**58.5**$^{+}$	23.8	0	10.3	9.8	18.3	**155.5**	575.5	60	***
	Clear cut	7.1	2.6	**9.7**$^{+}$	5.2	6.7	6.8	2.2	0	0	0	3.9	5.7	14.3			
	Partial cut/thinning	26.9	32.5	34.7	34.2	41.8	**46.1**$^{+}$	**22.2**$^{-}$	42.8	25.0	27.6	19.6	33.1	19.4			
	Burn	**3.2**$^{-}$	**19.5**$^{+}$	9.7	**22.6**$^{+}$	**4.2**$^{-}$	9.3	7.4	19.0	0	10.3	9.8	10.2	**46.9**			
	Swamp	**16.7**$^{+}$	0	**0**$^{-}$	**0**$^{-}$	**0.6**$^{-}$	0.8	**0**$^{-}$	0	**66.7**$^{+}$	**24.1**$^{+}$	3.9	4.0	**241.8**			
	Other	1.9	5.2	0.5	0	3.0	0	0	0	8.3	**10.3**$^{+}$	**15.7**$^{+}$	2.2	**67.5**			
	Nothing evident	26.3	33.8	29.1	**36.1**$^{+}$	26.7	25.4	**9.6**$^{-}$	14.3	0	17.2	37.3	26.4	**29.4**			
	χ^2: Group sums	**71.5**	**21.3**	**17.0**	**61.2**	**17.0**	11.6	**151.7**	6.2	**136.1**	**41.3**	**49.8**					
Status in 1935	Forest cover	85.9	96.1	86.2	89.7	86.7	80.5	**32.6**$^{-}$	71.4	100	79.3	78.4	79.6	**45.7**	224.8	10	***
	Cleared land	14.1	**3.9**$^{-}$	**13.8**$^{-}$	**10.3**$^{-}$	**13.3**$^{-}$	19.5	**67.4**$^{+}$	28.6	0	20.7	21.6	20.4	**179.8**			
	χ^2: Group sums	3.7	**12.8**	5.2	**9.6**	5.0	0.05	**184.3**	0.8	3.0	0.00	0.04					
Status in 1935 **+ evident origin**	Forest cover	73.1	89.6	74.5	**88.4**$^{+}$	75.8	70.3	**25.9**$^{-}$	66.7	100	72.4	74.5	71.2	**51.3**	178.3	10	***
	Cleared land	26.9	**10.4**$^{-}$	25.5	**11.6**$^{-}$	24.2	29.7	**74.1**$^{+}$	33.3	0	27.6	25.5	28.8	**137.0**			
	χ^2: Group sums	0.2	**12.7**	1.0	**22.3**	1.6	0.04	**138.0**	0.2	4.8	0.01	0.27					
NUMBER OF PLOTS		156	77	196	155	165	118	135	21	12	29	51	1115				

1. The percentages for which the corresponding χ^2 value was ≥ 3.84 ($p < 0.05$, df = 1) are printed in bold. For such percentages '+' or '−' indicates the nature of the association between the particular TWINSPAN group and the attribute class. Group or row χ^2 sums printed in bold are significant at $p < 0.01$ (for rows: df = 10; for groups: df varies with the number of classes, ie. = n-1).

2. p level = probability level
   * ($p < 0.05$)
   ** ($p < 0.01$)
   *** ($p < 0.001$)

TABLE 3-13. Qualitative field soil properties and aspect for the ground flora TWINSPAN groups. For each group the percentage of plot in each class is given. Those percentages printed in bold have made a greater contribution to the χ^2 value than those i plain text - see footnote 1.

ATTRIBUTE	CLASS	GROUND FLORA TWINSPAN GROUP											ALL PLOTS	χ^2 TEST OF ASSOCIATION[1]			
		3	5	6	7	8	9	10	11	12	13	14		χ^2: Row sums	TOTAL χ^2	df	p level
Soil texture	Clay	3.8	1.3	1.0	0·	7.3'	5.1	1.5	0	8.3	3.4	5.9	3.0	23.8	538.4	90	***
Fine	Silty clay	12.2'	0	0·	0.6	0·	3.4	0	0	8.3	6.9	3.9	2.6	77.0			
Moderately fine	Clay loam	10.3	11.7	13.8	14.8	15.8	16.1	13.3	19.0	0	10.3	5.9	13.3	7.4			
	Sandy clay loam	21.8	23.4	25.5	32.9	23.0	27.1	23.0	14.3	8.3	13.8	37.3	25.2	11.9			
Medium	Silty loam	0	0	2.6	3.3'	0	0	0.7	0	8.3	3.4	2.0	1.3	20.5			
	Loam	3.2·	42.9'	29.6	32.3	29.7	22.0	32.6	28.6	8.3	3.4	3.9	24.7	66.0			
Moderately coarse	Sandy loam	14.7	19.5	20.9	14.8	20.0	23.7	22.2	0·	0	13.8	21.6	18.7	12.7			
Coarse	Loamy sand	19.9'	1.3	6.1	1.3·	2.6·	2.5	5.9	38.1'	8.3	13.8	13.7	7.3	87.3			
	Sand	4.5'	0	0.5	0	1.8	0	0.7	0	8.3	0	3.9	1.3	25.5			
	Organic	9.6'	0	0·	0·	0·	0	0	0	41.7'	31.0'	2.0	2.7	205.0			
	χ^2: Group sums	163.1	21.1	19.8	36.6	28.9	14.5	13.8	38.6	86.2	99.2	21.6					
Soil drainage	Well drained	17.9·	83.1'	86.7'	93.8'	58.8	52.5	84.4'	90.5	0·	6.9·	19.6·	63.8	145.9	710.6	30	***
	Mode-ately well drained	23.7	11.7	11.2·	6.5·	18.2	41.5'	14.1	9.5	8.3	3.4	27.5	17.4	67.8			
	Imperfectly drained	16.0'	5.2	1.5·	0	20.6'	4.2	1.5·	0	16.7	20.7'	29.4'	8.6	107.1			
	Poorly drained	42.3'	0·	0.5·	0·	2.6·	1.7	0·	0	75.0'	69.0'	23.5'	10.2	309.6			
	χ^2: Group sums	222.1	16.8	49.9	61.4	38.0	52.8	31.6	7.0	58.7	120.9	53.0					

ATTRIBUTE	CLASS	GROUND FLORA TWINSPAN GROUP											ALL PLOTS	χ^2 TEST OF ASSOCIATION[1]			
		3	5	6	7	8	9	10	11	12	13	14		χ^2: Row sums	TOTAL χ^2	df	p level
Root restriction factors	Water table	28.2^{+}	0^{-}	0^{-}	0^{-}	0.6^{-}	0^{-}	0^{-}	0	58.3^{+}	31.0^{+}	3.9	5.6	280.9	297.4	10	***
	Soil compaction	71.8^{-}	100	100	100	99.4	100	100	100	41.7	69.0	96.1	94.3	16.4			
	χ^2: Group sums	148.9	4.6	11.7	9.2	7.8	6.8	8.8	1.1	63.3	35.2	0.2					
Aspect	Level	68.6^{+}	20.8^{-}	27.0^{-}	19.4^{-}	33.3	46.6	17.8^{-}	14.3	83.3^{+}	93.1^{+}	66.7^{+}	37.1	139.1	285.2	80	***
	North	5.8^{-}	15.6	14.8	17.4^{+}	10.9	11.0	8.9	4.8	8.3	0	5.9	11.2	19.0			
	North-east	1.9^{-}	10.4	12.2	9.0	7.3	11.0	10.4	4.8	0	6.9	5.9	8.4	15.3			
	East	2.6^{-}	2.6	9.2	11.6^{+}	4.8	6.8	12.6^{+}	4.8	0	0	2.0	6.9	24.8			
	South-east	2.6	7.8	5.1	11.0^{+}	6.1	2.5	10.4	23.8^{+}	0	0	0	6.2	22.3			
	South	3.2^{-}	19.5^{+}	6.1	7.1	12.1	4.2	13.3^{+}	9.5	8.3	0	7.8	8.3	29.5			
	South-west	3.8	9.1	6.6	5.2	7.3	7.6	12.6^{+}	14.3	0	0	2.0	6.8	16.2			
	West	5.1	6.5	10.2	8.4	9.1	5.9	5.2	9.5	0	0	3.9	7.1	9.5			
	North-west	6.4	7.8	8.7	11.0	9.1	4.2	8.9	14.3	0	0	5.9	7.9	9.4			
	χ^2: Group sums	69.3	21.6	16.8	32.4	6.0	11.0	36.4	17.8	12.1	40.3	21.3					
NUMBER OF PLOTS		156	77	196	155	165	118	135	21	12	29	51	1115				

1. The percentages for which the corresponding χ^2 value was ≥ 3.84 ($p < 0.05$, $df = 1$) are printed in bold. For such percentages '+' or '-' indicates the nature of the association between the particular TWINSPAN group and the attribute class. Group or row χ^2 sums printed in bold are significant at $p < 0.01$ (for rows: $df = 10$; for groups: df varies with the number of classes, ie. $= n-1$).

2. p level = probability level
   * ($p < 0.05$)
   ** ($p < 0.01$)
   *** ($p < 0.001$)

TABLE 3-14. The mean values (±S.E.) for pH, carbon, total nitrogen and the available macronutrients in the ground flora TWINSPAN groups. (The letters in each box refer to Scheffe multiple comparison tests - see footnote).

SOIL FACTOR	SOIL HORIZON	GROUND FLORA TWINSPAN GROUP											ONE-WAY ANOVA[*]		
		3	5	6	7	8	9	10	11	12	13	14	F	P	P level
pH	H	5.4 (0.08) a	4.3 (0.06) ac	4.3 (0.04) ad	4.2 (0.03) a	4.2 (0.04) a	4.0 (0.04) ab	4.2 (0.04) a	4.4 (0.13) a	4.9 (0.34) b	3.9 (0.18) ab	3.9 (0.04) abcd	61.2	0.0000	***
	B	6.2 (0.06) a	5.0 (0.04) a	5.0 (0.04) a	4.9 (0.03) ab	5.2 (0.04) ab	5.1 (0.04) a	5.1 (0.03) a	5.1 (0.06) a	5.6 (0.37)	5.0 (0.15) a	4.9 (0.06) a	76.3	0.0000	***
Carbon (%)	H	22.1 (1.2) abg	19.5 (1.4) abcg	13.5 (0.72) abcdef	11.9 (0.67) abcdefg	23.0 (0.87) ad	21.6 (1.1) abcf	14.0 (0.85) abcdef	15.8 (2.3) abc	37.8 (2.4) b	33.7 (2.4) a	29.7 (1.8) c	30.2	0.000	***
	B	0.86 (0.38)	1.33 (0.11)	0.90 (0.05)	1.11 (0.07)	0.84 (0.05)	1.07 (0.28)	0.97 (0.13)	0.10 (0.13)	1.30 (0.80)	2.71 (1.65)	0.86 (0.10)	1.70	0.074	n.s.
Nitrogen (%)	H	1.31 (0.10) b	0.99 (0.06)	0.73 (0.07) ab	0.60 (0.03) abc	1.04 (0.04) c	0.96 (0.08)	0.65 (0.03) abc	0.77 (0.11)	1.72 (0.13) a	1.11 (0.08)	0.95 (0.06)	11.5	0.0000	***
	B	0.074 (0.018)	0.100 (0.006)	0.085 (0.004)	0.105 (0.007)	0.075 (0.004)	0.085 (0.009)	0.085 (0.006)	0.072 (0.006)	0.097 (0.024)	0.110 (0.043)	0.070 (0.008)	1.46	0.147	n.s.
Phosphorus (ppm)	H	112 (8.2) a	208 (14.5) a	173 (8.1) a	181 (7.3) a	239 (13.7) a	199 (12.9) a	179 (10.1) a	266 (36.8) a	123 (27.8)	167 (25.7)	154 (14.8)	9.9	0.0000	***
	B	43 (3.9) abc	82 (9.7) a	107 (7.0) b	140 (9.9) a	68 (6.7) a	86 (9.9) a	97 (8.0) c	80 (18.0)	40 (18.3)	95 (22.6)	45 (6.7) a	10.8	0.0000	***

SOIL FACTOR	SOIL	GROUND FLORA TWINSPAN GROUP											ONE-WAY ANOVA*		
	HORIZON	3	5	6	7	8	9	10	11	12	13	14	F	p	p level
Sulphur (ppm)	H	74.8 (5.3) a	46.3 (2.7)	37.0 (1.5) a	38.0 (2.5) a	58.8 (4.7)	50.4 (3.9)	42.5 (4.9) a	44.1 (4.7)	86.9 (10.9)	62.1 (8.5)	71.6 (17.4)	7.75	0.0000	***
	B	11.2 (0.92) a	27.0 (2.9)	29.8 (1.3)	36.1 (6.1)	37.2 (4.1)	51.1 (10.2) a	38.7 (5.0)	41.0 (4.9)	17.0 (5.7)	22.5 (2.6)	34.2 (3.2)	3.70	0.0001	***
Potassium (ppm)	H	176 (14.9) abcd	310 (20.8) d	219 (12.0) abc	232 (13.4) ab	376 (19.2) a	328 (21.7) c	253 (16.2) a	357 (52.8)	195 (39.3)	309 (32.7)	375 (32.0) b	13.3	0.0000	***
	B	46.5 (5.1) a	31.6 (1.4)	31.2 (1.4) a	30.7 (1.7) a	34.4 (0.97)	36.0 (3.7)	34.4 (3.1)	29.0 (2.5)	38.8 (7.4)	43.8 (5.9)	30.1 (1.6)	2.97	0.0011	**
Calcium (ppm)	H	5100 (300) a	1170 (187) ab	894 (75) ab	526 (29) ab	1160 (98) ab	831 (72) ab	644 (42) ab	756 (84) ab	4080 (1110) b	984 (136) ab	860 (264) ab	86.3	0.0000	***
	B	1080 (133) a	200 (27) a	188 (26) a	112 (5.4) a	241 (22) a	208 (33) a	149 (13) a	119 (8.0) a	367 (151)	330 (63) a	148 (9.7) a	28.5	0.0000	***
Magnesium (ppm)	H	757 (115) ab	275 (19) ab	316 (82) ab	191 (13) ab	361 (24) ab	329 (28) ab	203 (16) ab	224 (32) a	1800 (680) a	463 (51) a	415 (36) a	9.87	0.0000	***
	B	110 (9.4) a	42 (6.9) a	37 (2.8) ab	29 (2.5) ab	54 (4.5) a	44 (4.3) a	38 (5.3) ab	28 (2.7) a	81 (19)	102 (30) b	36 (2.8) a	18.0	0.0000	***
Number of plots		156	77	196	155	165	118	135	21	12	29	51			

* One-way ANOVA (df = 10). Means with the same letter are significantly different from a mean with an underlined letter. 'a' is significantly different from 'a' (Scheffe multiple comparison test, p < 0.05)

p level = probability level:
- * (p < 0.05)
- ** (p < 0.01)
- *** (p < 0.001)
- n.s. not significant

TABLE 3-15. The mean values (±S.E.) for the available soil micronutrients in the ground flora TWINSPAN groups. (The superscript letters refer to Scheffe multiple comparison tests - see footnote).

MICRONUTRIENT	SOIL HORIZON	GROUND FLORA TWINSPAN GROUP											ONE-WAY ANOVA*		
		3	5	6	7	8	9	10	11	12	13	14	F	p	p level
Boron (ppm)	H	0.91$^{\underline{a}}$ (0.057)	0.32^{a} (0.020)	0.46^{a} (0.041)	0.40^{a} (0.046)	0.44^{a} (0.048)	0.32^{a} (0.016)	0.34^{a} (0.018)	0.40 (0.041)	0.69 (0.16)	0.45^{a} (0.059)	0.36^{a} (0.050)	13.8	0.0000	***
	B	0.37 (0.14)	0.22^{a} (0.019)	0.25^{a} (0.011)	0.27^{a} (0.029)	0.21^{a} (0.011)	0.20^{a} (0.014)	0.23^{a} (0.015)	1.30$^{\underline{a}}$ (1.09)	0.20 (0.030)	0.26 (0.035)	0.20^{a} (0.016)	2.88	0.001	**
Copper (ppm)	H	1.75 (0.31)	0.98 (0.071)	1.05 (0.18)	0.81 (0.057)	0.91 (0.043)	2.22 (1.34)	1.12 (0.27)	0.75 (0.11)	0.82 (0.11)	1.88 (0.96)	5.38 (3.4)	1.79	0.497	*
	B	1.03 (0.58)	0.48 (0.09)	1.96 (0.90)	1.27 (0.86)	0.39 (0.03)	1.00 (0.67)	1.48 (1.1)	4.76 (4.4)	0.51 (0.12)	0.49 (0.09)	0.40 (0.03)	0.66	0.77	n.s.
Iron (ppm)	H	237 (8.7)	209 (13.1)	273 (9.2)	255 (10.7)	249 (9.3)	252 (10.0)	269 (9.2)	209 (21.8)	199 (19.0)	274 (26.9)	248 (12.3)	2.92	0.0008	***
	B	111^{a} (5.9)	152 (11.0)	137 (7.7)	131 (8.2)	151 (8.0)	156 (9.2)	126^{a} (7.1)	85^{a} (10.2)	140 (46.1)	193 (23.9)	197$^{\underline{a}}$ (13.9)	4.98	0.0000	***
Manganese (ppm)	H	108 (13.3)	140 (13.0)	139 (10.8)	154$^{\underline{a}}$ (12.6)	143 (12.5)	109 (11.9)	130 (11.8)	172 (22.0)	71 (41.9)	60 (18.1)	46^{a} (8.5)	4.41	0.0000	***
	B	73.0$^{\underline{a}}$ (8.4)	20.7^{a} (3.5)	18.4^{a} (1.9)	12.2^{a} (1.3)	19.4^{a} (2.5)	17.3^{a} (2.2)	13.7^{a} (1.3)	10.3^{a} (2.0)	7.9 (3.4)	33.7 (13.6)	4.5^{a} (1.0)	21.1	0.0000	***
Zinc (ppm)	H	8.5 (0.58)	10.4 (0.93)	8.3 (0.65)	6.8$^{\underline{a}}$ (0.40)	10.6^{a} (0.56)	11.2^{a} (0.71)	8.3 (0.73)	11.5 (2.0)	9.2 (2.4)	9.0 (1.5)	11.5 (1.1)	4.31	0.0000	***
	B	1.5 (0.44)	1.2 (0.07)	1.3 (0.14)	1.4 (0.16)	1.2 (0.09)	1.2 (0.13)	1.2 (0.16)	1.5 (0.53)	0.86 (0.14)	1.1 (0.25)	0.86 (0.05)	1.17	0.0000	n.s.
Number of plots		156	77	196	155	165	118	135	21	12	29	51			

* One-way ANOVA (df = 10). Means with the same superscript are significantly different from a mean with an underlined letter, 'a' is significantly different from 'a' (Scheffe multiple comparison test, $p < 0.05$)

p level = probability level:
- * ($p < 0.05$)
- ** ($p < 0.01$)
- *** ($p < 0.001$)
- n.s. not significant

TABLE 3-16. The mean values (±S.E.) for soil profile measurements and slope in the ground flora TWINSPAN groups. (The letters in each box refer to Scheffe multiple comparison tests - see footnote).

SOIL PROPERTY	GROUND FLORA TWINSPAN GROUP											ONE-WAY ANOVA*		
	3	5	6	7	8	9	10	11	12	13	14	F	P	p level
A-horizon thickness (cm)	30.6 (1.7) $\underline{c}$	18.4 (0.74) abc	19.6 (0.67) abc	18.9 (0.60) abc	22.0 (0.73) abc	24.6 (1.1) a	24.0 (0.81) ac	19.5 (2.2) a	32.2 (5.5)	38.6 (4.3) $\underline{a}$	31.5 (1.5) $\underline{b}$	18.2	0.0000	***
Rooting depth (cm)	59.2 (2.0) a	54.3 (1.5)	57.6 (0.99)	54.6 (0.99)	56.1 (1.1)	57.7 (1.4)	62.5 (1.4) a	60.3 (2.2)	37.3 (5.8) $\underline{a}$	53.3 (4.6)	51.0 (2.1)	5.03	0.0000	***
Slope (%)	1.7 (0.16)	2.1 (0.19)	2.5 (0.14) a	2.4 (0.17)	1.7 (0.13)	1.5 (0.13) $\underline{a}$	1.9 (0.15)	2.0 (0.30)	1.0 (0)	1.6 (0.45)	1.5 (0.27)	4.47	0.0000	***
Number of plots	156	77	196	155	165	118	135	21	12	29	51			

* One-way ANOVA (df = 10). Means with the same letter are significantly different from a mean with an underlined letter, 'a' is significantly different from '$\underline{a}$' (Scheffe multiple comparison test, $p < 0.05$)

p level = probability level:

*	($p < 0.05$)
**	($p < 0.01$)
***	($p < 0.001$)
n.s.	not significant

TABLE 3-17. The soil series for the 1200 Inventory plots subdivided according to ground flora TWINSPAN groups.

SOIL SERIES	DRAINAGE CLASS[1]	% OF ISLAND LAND SURFACE[2]	GROUND FLORA TWINSPAN GROUP											Other Inventory Plots[3]	TOTAL PLOTS	% of Plots	χ^2 [4]
			3	5	6	7	8	9	10	11	12	13	14				
Abney Road	*p(o)*	0.10	1					1							2	0.17	0.45
Alberry	*w*	18.0	5	22	39	32	36	14	21	8	1	1	1	9	189	15.8	3.4
Baptist Point	*p*	2.1	13				9	4			1	2	3	2	34	2.8	2.9
Brackley	*i*	0.21	1												1	0.083	0.94
Bunbury	*w or r*	0.036											2	1	3	0.25	15.0*
Carey Point	*i*	0.27	1												1	0.083	1.5
Charlottetown	*w*	34.2	12	34	89	88	37	22	49	9	2	3	2	27	374	31.2	3.1
Crapaud	*i*	0.74		1									2		3	0.25	3.8
Culloden	*w or r*	10.5	7	7	17	17	21	29	37	3		1	10	4	153	13.0	5.8*
Dunstaffnage	*w or r*	0.49					1	2	2						5	0.42	0.13
Duvar	*i*	1.5	7	1	5	1	5	4	1	1			2	1	28	2.3	5.5*
Emyvale	*w*	0.054			1	3									4	0.33	17.6*
Fifteen Point	*m*	0.15				1									1	0.083	0.31
Gowanbrae	*w or r*	0.62					1		1					4	6	0.50	0.27
Haliburton	*w*	1.3	6				2	1	2						11	0.92	1.3
Kildare	*w*	1.2		1	4		1	1							7	0.58	4.1*
Lake Verde	*p(o)*	0.12	1										2	3	6	0.42	14.2*
Lochs Road	*p*	0.0089	3		2		3	3	1				1		13	1.1	1568*
Malpeque	*i*	3.2	11	3	6		11	5	1		1	1	2	4	45	3.8	1.0
Margate	*p*	4.5	5	1	2	2	10	10	4		2		2	3	41	3.4	2.9
Mossy Point	*p*	2.6	15		5	2	1	3	2			6	2	1	37	3.2	0.92

SOIL SERIES	DRAINAGE CLASS[1]	% OF ISLAND LAND SURFACE[2]	GROUND FLORA TWINSPAN GROUP											Other Inventory Plots[3]	TOTAL PLOTS	% of Plots	χ^2 [4]
			3	5	6	7	8	9	10	11	12	13	14				
O'Leary	*m*	2.1	1		2	4	2	2	1				1	1	14	1.2	**6.5**$^{+}$
Orwell	*p*	1.4	5		1		5	2			1	6	8	5	33	2.6	**15.1**$^{+}$
Pisquid	*p(o)*	0.076										2		1	3	0.25	**6.7**$^{+}$
Rocky Point	*p*	1.6	24		2		2	4			1	1		4	38	3.1	**17.4**$^{+}$
Salt Grass Point	*i*	1.6	5		2		2	2	1			1	2	2	17	1.4	0.19
Tignish	*w*	2.5		2	5	5	3	2	3					6	26	2.2	0.48
Uigg	*i*	1.2	1	2	1		2	2	3			1	4	4	20	1.7	1.6
West Point	*i*	0.82	5		3		1	2							11	0.92	0.13
Winsloe	*p*	2.1	19	2	4		8	2	3		2	4	3		47	3.9	**19.9**$^{+}$
Wood Island	*p*	0.38					1	1							2	0.17	0.13
Stream complex	*p*	2.4	8	1	6		1		3		1		2	2	24	2.0	0.63
12 remaining soil series	-	1.7												1	1	0.08	**18.9**
GROUP TOTALS			156	77	196	155	165	118	135	21	12	29	51	85	1200	100	1738.1

Footnotes:

1. Drainage classes are those listed for each soil series in MacDougall *et al.* (1988) (pp. 20-22): *w* or *r* - well or rapidly drained; *w* - well drained; *m* - moderately well drained; p - poorly drained; *p(o)* - poorly drained (organic soil).

2. The percentage of the island's land surface occupied by each soil series was obtained from data in MacDougall *et al.*, (1988) (pp. 20-22) - taking 550,905 hectares as the total island land area (i.e. subtracting 'miscellaneous landtypes' with the exception of 'stream complex').

3. The 85 'other Inventory plots' comprise the 12 plots in the four small TWINSPAN groups of less than ten plots, plus 53 plots excluded from the analysis because there were no trees at the sampling point, and 20 plots excluded because no ground flora were present in the sample plot.

4. The χ^2 goodness-of-fit analysis compares the observed soil series allocation for the 1200 Inventory plots with that expected if the allocation had been proportional to the percentage of the island's ground area occupied by each soil series (see footnote 2 above). Individual χ^2 values ≥ 3.84 ($p < 0.05$, $df = 1$) are printed in bold: a '+' indicates that the soil type occurred in the Inventory plots more frequently than expected, a '-'' less frequently. For all of the soil series analyzed above $\chi^2 = 1738.1$ ($df = 32$, $p <<< 0.001$); excluding the Locke Road series (which had an exceptionally high χ^2): $\chi^2 = 169.3$ ($df = 31$, $p << 0.001$).

TABLE 3-18.(a) - The principal soil series of the ground flora TWINSPAN groups - only those series recorded in at least 20 plots of the eleven TWINSPAN groups are listed. (b) - The soil series of the ground flora TWINSPAN groups - grouped into four drainage classes on the basis of the descriptions in MacDougall *et al.* (1988) (pp. 20-22). For each TWINSPAN group the percentage of plots of each soil series or drainage group is given. Those percentages printed in bold have made a greater contribution to the χ^2 value than those in plain text - see footnote 1.

ATTRIBUTE	CLASS	GROUND FLORA TWINSPAN GROUP											ALL	χ^2 TEST OF ASSOCIATION[1]			
		3	5	6	7	8	9	10	11	12	13	14	PLOTS	χ^2: Row sums	TOTAL χ^2	df	p level
(a) Soil Series																	
rapidly drained series	Culloden	4.5^{-}	9.1	8.7	11.0	12.7	24.6^{+}	27.6^{+}	14.3	0	3.4	19.6	13.4	50.4	681.2	169	***
well drained series	Alberry	3.2^{-}	28.6^{+}	19.9	20.6	21.8	11.9	15.6	38.1^{+}	8.3	3.4	2.0^{-}	16.1	47.7			
	Charlottetown	7.7^{-}	44.2^{+}	45.6^{+}	56.8^{+}	22.4^{-}	18.6^{-}	36.3	42.9	16.7	10.3^{-}	3.9^{-}	31.1	106.2			
	Tignish	0	2.6	2.6	1.2	1.8	1.7	2.2	0	0	0	0	1.8	7.6			
imperfectly drained series	Duvar	4.5	1.3	2.6	0.65	3.0	3.4	0.74	4.8	0	0	3.9	2.4	9.3			
	Malpeque	7.1^{+}	3.9	3.1	0^{-}	6.7^{+}	4.2	0.74	0	8.3	3.4	3.9	3.7	18.8			
poorly drained series	Baptist Point	8.3^{+}	0	0^{-}	0^{-}	5.5^{+}	3.4	0^{-}	0	8.3	6.9	5.9	2.9	41.6			
	Margate	3.2	1.3	1.0	1.3	6.1	8.5^{+}	3.0	0	16.7	0	3.9	3.4	26.8			
	Mossy Point	9.6^{+}	0	2.6	1.3	0.61	2.5	1.5	0	0	20.7^{+}	3.9	3.2	57.7			
	Orwell	3.2	0	0.51	0^{-}	3.0	1.7	0	0	8.3	20.7^{+}	15.7^{+}	2.5	115.6			
	Rocky Point	15.4^{+}	0	1.0	0^{-}	1.2	3.4	0^{-}	0	8.3	3.4	0	3.0	96.9			
	Winsloe	12.3^{+}	2.6	2.0	0^{-}	4.8	1.7	2.2	0	16.7	13.8^{+}	5.9	4.2	47.9			
	Stream complex	5.1^{+}	1.3	3.1	0	0.61	0	2.2	0	8.3	0	3.9	2.0	20.7			
	Remaining series	16.0	5.2	7.7	5.2	9.7	14.4	8.1	0	0	13.8	27.5^{+}	10.0	33.3			
	χ^2: Group sums	214.0	25.7	38.1	75.2	26.1	34.6	40.7	15.4	22.4	85.6	102.8					

ATTRIBUTE	CLASS	GROUND FLORA TWINSPAN GROUP											ALL	χ^2 TEST OF ASSOCIATION[1]			
		3	5	6	7	8	9	10	11	12	13	14	PLOTS	χ^2: Row sums	TOTAL χ^2	df	p level
(b) Soil Series	Well to rapidly drained series	6.5^{-}	9.1	8.7^{-}	11.0	13.9	26.3^{+}	29.6^{+}	14.3	0	3.4	23.5	14.2	59.1	448.8	30	***
(grouped as four drainage classes)	Well or moderately well drained series	15.4^{-}	76.6^{+}	71.4^{+}	85.8^{+}	49.1	35.6^{-}	56.3	81.0	25.0	13.8^{-}	7.8^{-}	52.3	135.8			
	Imperfectly drained series	20.0^{+}	9.1	8.7	0.65^{-}	12.7	12.7	4.4^{-}	4.8	8.3	10.3	23.9^{+}	10.3	43.8			
	Poorly drained series	60.3^{+}	5.2^{-}	11.2^{-}	2.6^{-}	24.2	25.4	9.6^{-}	0^{-}	66.6^{+}	72.4^{+}	45.1^{+}	23.2	209.9			
	χ^2: Group sums	156.8	21.0	30.5	76.9	1.3	19.3	38.4	8.7	13.2	40.8	41.5					
NUMBER OF PLOTS		156	77	196	155	165	118	135	21	12	29	51	1115				

Footnotes:

1. The percentages for which the corresponding χ^2 was ≥ 3.84 ($p<0.05$, df=1) are printed in bold. For such percentages, a '+' or '-' indicates the nature of the association between the particular TWINSPAN group and the attribute class.
Group or row χ^2 sums printed in bold are significant at $p<0.01$ (for rows: df=10; for groups: df=13 or 3).

2. p level
    - * ($p < 0.05$)
    - ** ($p < 0.01$)
    - *** ($p < 0.001$)

TABLE 3-19. The spatial association of the different ground flora TWINSPAN groups at the 240 sampling sites. For each group its percentage association with each of the other TWINSPAN groups (including itself) on the same site is given.[1] Those percentages printed in bold have made a greater contribution to the χ^2 value than those in plain test - see footnote 3.

GROUND FLORA TWINSPAN GROUP	ASSOCIATED GROUND FLORA TWINSPAN GROUP											OTHER INVENTORY PLOTS	χ^2 [3]	p level [3]
	3	5	6	7	8	9	10	11	12	13	14			
3	**49.4**$^+$	4.8	**10.1**$^-$	**0.64**$^-$	12.0	9.1	**3.7**$^-$	**0.32**$^-$	1.1	**0.96**$^-$	**2.6**$^-$	5.3	777.9	***
5	9.7	**32.5**$^+$	**26.0**$^+$	15.9	**8.8**$^-$	**1.9**$^-$	**2.3**$^-$	0.32	0.32	**0.32**$^-$	**0**	1.9	430.1	***
6	**8.0**$^-$	**10.2**$^+$	**27.8**$^+$	**20.4**$^+$	13.8	**5.1**$^-$	**5.0**$^-$	1.5	0.64	**0.77**$^-$	**1.0**$^-$	5.7	206.2	***
7	**0.65**$^-$	7.9	**25.8**$^+$	**37.7**$^+$	**7.1**$^-$	**3.2**$^-$	9.8	2.2	**0**$^-$	**0.65**$^-$	**0.32**$^-$	**4.5**$^-$	496.8	***
8	11.4	**4.1**$^-$	16.4	**6.7**$^-$	**20.6**$^+$	**13.5**$^+$	8.9	2.1	1.7	3.3	4.8	6.5	68.0	***
9	12.1	**1.3**$^-$	**8.5**$^-$	**4.2**$^-$	**18.9**$^+$	**26.3**$^+$	10.8	1.9	1.3	3.4	**7.8**$^+$	**3.6**	228.4	***
10	**4.3**$^-$	**1.3**$^-$	**7.2**$^-$	11.3	10.9	9.4	**38.9**$^+$	**3.1**$^+$	1.1	1.7	4.3	6.5	459.7	***
11	**2.4**$^-$	1.2	14.3	16.7	16.7	10.7	**20.2**$^+$	**7.1**$^+$	0	0	3.6	7.1	35.5	***
12	14.6	2.1	10.4	**0**$^-$	22.9	12.5	12.5	0	**8.3**$^+$	6.3	6.3	4.2	42.6	***
13	**5.2**$^-$	**0.86**	**5.2**$^-$	**3.4**$^-$	19.0	13.8	7.8	0	2.6	**22.4**$^+$	**9.5**$^+$	10.3	239.6	***
14	**7.8**$^-$	**0**$^-$	**3.9**$^-$	**0.98**$^-$	15.7	**18.1**$^+$	11.3	1.5	1.5	**5.4**$^+$	**25.5**$^+$	8.3	298.6	***
Other Inventory Plots [2]	9.7	**1.8**$^-$	13.2	**8.2**$^-$	12.6	**5.0**$^-$	10.3	1.8	0.59	3.5	5.0	**28.2**$^+$	248.2	***
NUMBER OF PLOTS	156	77	196	155	165	118	135	21	12	29	51	85		
Percentage Of Plots	13.0	6.4	16.3	12.9	13.8	9.8	11.3	1.8	1.0	2.4	4.3	7.1		

1. The percentage association was calculated as follows: each ground flora plot in a group of five at a sampling site was scored on the basis of the TWINSPAN class of each of the other four plots at that site, and values for all of the plots in a TWINSPAN group were totalled. Thus, as an example: the 156 plots of TWINSPAN Group 3 had 624 (ie. 156 x 4) associates - 49.4% of these (ie. 308) were other plots of TWINSPAN Group 3, 4.8% (ie. 30) were plots of TWINSPAN Group 5, and so on.

2. The 85 'other Inventory plots' comprise the 12 plots in the four small TWINSPAN groups of less than ten plots, plus 53 plots excluded from the analysis because there were no trees at the sampling point, and 20 plots excluded because no ground flora were present in the sample plot.

3. For each TWINSPAN group, a χ^2 goodness-of-fit analysis (df = 11) compares the distribution of its observed percentage associations with each of the other TWINSPAN groups, with that expected if the distribution had been proportional to the percentage of the 1200 plots in each TWINSPAN group - ie. to the 'Percentage of Plots' at the base of the Table. Those percentages for which the individual χ^2 values were ≥ 3.84 ($p < 0.05$, df = 1) are printed in bold: a '+' indicates that the level of association was higher than expected, a '-' lower. (For df = 11, if $\chi^2 \geq 31.26$, $p \leq 0.001$ - indicated by '***').

TABLE 3-20. (a) The percentage of the plots in each TWINSPAN group falling into three different size classes in terms of the area (km^2) of the woodland in which they occur - as determined from 1:50,000 maps. Those percentages printed in bold have made a greater contribution to the χ^2 value than those in plain text - see footnote 1.

(b) For those plots falling in the ≤ 5 km^2 size class the mean area (km^2) (± S.E.) is given for each TWINSPAN group.

(a) Class Size of Wooded Area	GROUND FLORA TWINSPAN GROUP											ALL	χ^2 TEST OF ASSOCIATION^2			
	3	5	6	7	8	9	10	11	12	13	14	PLOTS	χ^2: Row sums	TOTAL χ^2	df	p^2 level
≤ 5 km^2	44.2	36.4	**68.4^{+}**	**56.8^{+}**	38.8	35.6	44.4	28.6	16.7	41.4	**13.7^{-}**	45.9	**46.9**	161.4	20	***
> 5 - 10 km^2	23.7	**40.3^{+}**	16.8	27.1	**12.7^{-}**	15.3	21.5	28.6	25.0	20.7	11.8	20.8	**28.7**			
> 10 km^2	32.1	23.4	**14.8^{-}**	**16.1^{-}**	**48.5^{+}**	**49.2^{+}**	34.1	42.9	58.3	37.9	**74.5^{+}**	33.3	**85.7**			
χ^2: Group Sums	0.80	**17.7**	**43.0**	**20.6**	**18.4**	**13.4**	0.11	2.5	4.6	0.32	**39.6**					
NUMBER OF PLOTS	156	77	196	155	165	118	135	21	12	29	51	1115				
(b) Mean Size of Wooded Area (km^2)^3	1.33 (0.13)	1.31 (0.24)	1.10 (0.09)	1.20 (0.13)	1.18 (0.14)	1.74 (0.21)	1.17 (0.14)	1.24 (0.37)	0.39 (0)	0.89 (0.27)	1.12 (0.49)					
NUMBER OF PLOTS	69	28	134	88	64	42	60	6	2	12	7	512				

1. Those percentages for which the corresponding χ^2 was ≥ 3.84 ($p < 0.05$, df = 1) are printed in bold. For such percentages a '+' or '-' indicates the nature of the association between the particular TWINSPAN group and the size class.
   Column or group χ^2 sums printed in bold are significant at $p < 0.01$: (for rows: df = 10; for groups: df = 2)

2. p level = probability level *** ($p < 0.001$)

3. One way ANOVA (df = 10): F = 1.31, p = 0.220 (n.s.)

TABLE 3.21. The mean value (± S.E.) for each of the ground flora TWINSPAN groups of four attributes assessed from maps of the island: (1) Distance from the coast; (2) Distance from the nearest road or building; (3) Elevation above sea-level; (4) Corn heat units. (The letters in each box refer to Scheffe multiple comparison tests - see footnote.)

MAP ATTRIBUTE	GROUND FLORA TWINSPAN GROUP											ONE-WAY ANOVA*		
	3	5	6	7	8	9	10	11	12	13	14	F	p	p level
Distance from coast (km)	4.7 (0.32) ab	7.8 (0.45) a	5.7 (0.27) b	7.6 (0.34) b	5.3 (0.35) ab	5.2 (0.32) ab	6.7 (0.42)	5.6 (0.63)	7.7 (1.4)	3.6 (0.64) ab	5.5 (0.56)	8.15	0.0000	***
Distance from road/building (m)	454 (26)	597 (40) a	491 (23)	477 (23)	471 (28)	523 (37)	379 (23) a	495 (79)	392 (99)	496 (103)	332 (43) a	3.44	0.0002	***
Elevation (m)	19.5 (1.2) abcde	47.5 (2.6) b	36.9 (1.6) ad	50.4 (1.7) a	28.0 (1.4) abd	21.6 (1.3) abcde	36.1 (1.9) ae	42.2 (4.2) c	25.2 (3.6) a	19.1 (2.9) abde	19.6 (1.6) abcde	35.0	0.0000	***
Corn heat units (+2000)	304 (3.8)	323 (5.8) a	321 (3.6) a	325 (3.9) ab	302 (3.9) b	305 (4.6)	308 (3.8)	311 (10.6)	306 (16.6)	288 (8.6)	284 (5.6) a	5.93	0.0000	***
NUMBER OF PLOTS	156	77	196	155	165	118	135	21	12	29	51			

* One-way ANOVA, (df=10). Means with the same letter are significantly different from a mean with an underlined letter, 'a' is significantly different from a (Scheffe multiple comparison test, $p < 0.05$).

p level = probability level

*	($p < 0.05$)
**	($p < 0.01$)
***	($p < 0.001$)
n.s.	not significant

APPENDIX 4

DECORANA ordination of 1127 of the 4 m^2 ground flora plots assessed in the 1991 Prince Edward Island Forest Inventory. For each of the TWINSPAN groups, the figures show the positions of the individual plots along the first and second DECORANA axes.

FIGURE 4-1. TWINSPAN GROUP 3
FIGURE 4-2. TWINSPAN GROUP 5
FIGURE 4-3. TWINSPAN GROUP 6
FIGURE 4-4. TWINSPAN GROUP 7
FIGURE 4-5. TWINSPAN GROUP 8
FIGURE 4-6. TWINSPAN GROUP 9
FIGURE 4-7. TWINSPAN GROUP 10
FIGURE 4-8. TWINSPAN GROUP 11
FIGURE 4-9. TWINSPAN GROUP 12
FIGURE 4-10. TWINSPAN GROUP 13
FIGURE 4-11. TWINSPAN GROUP 14
FIGURE 4-12. TWINSPAN GROUPS 1, 2, 4 and 15
FIGURE 4-13. TWINSPAN GROUP 3A
FIGURE 4-14. TWINSPAN GROUP 3B

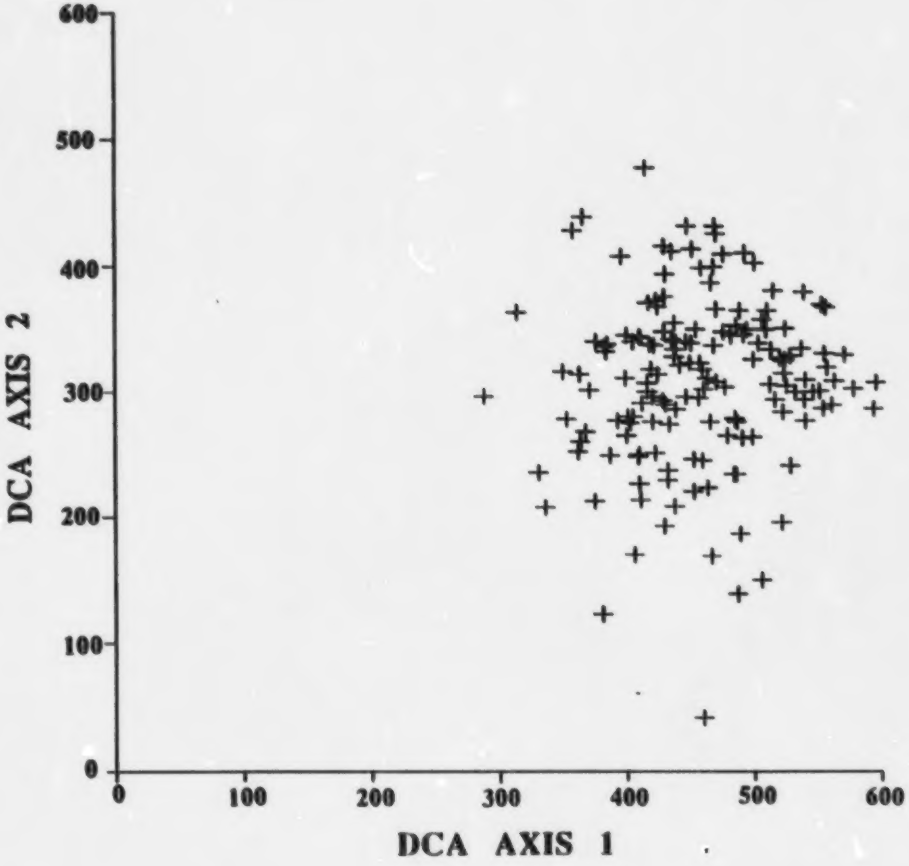

FIGURE 4-1. TWINSPAN GROUP 3

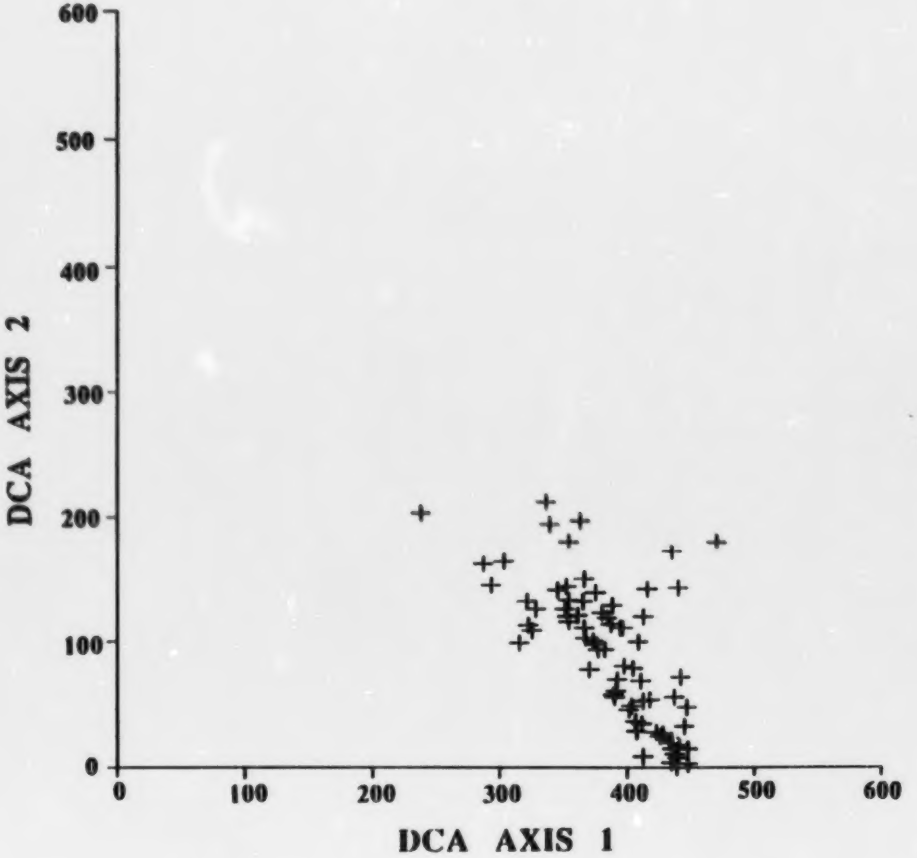

FIGURE 4-2. TWINSPAN GROUP 5

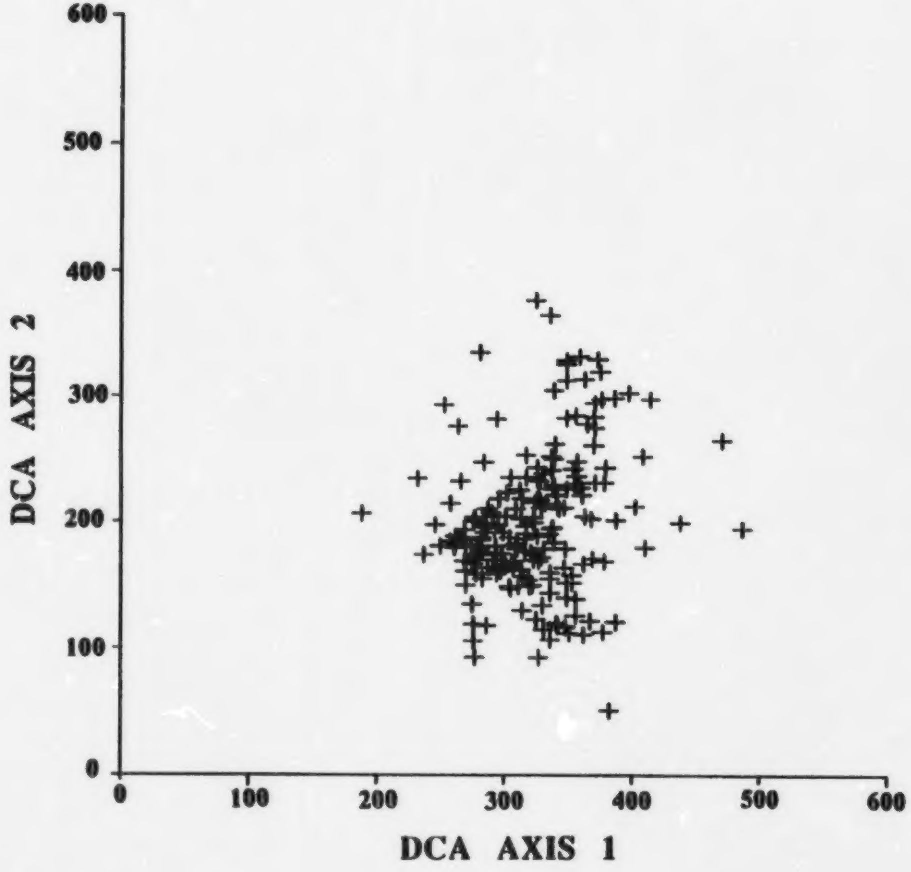

FIGURE 4-3. TWINSPAN GROUP 6

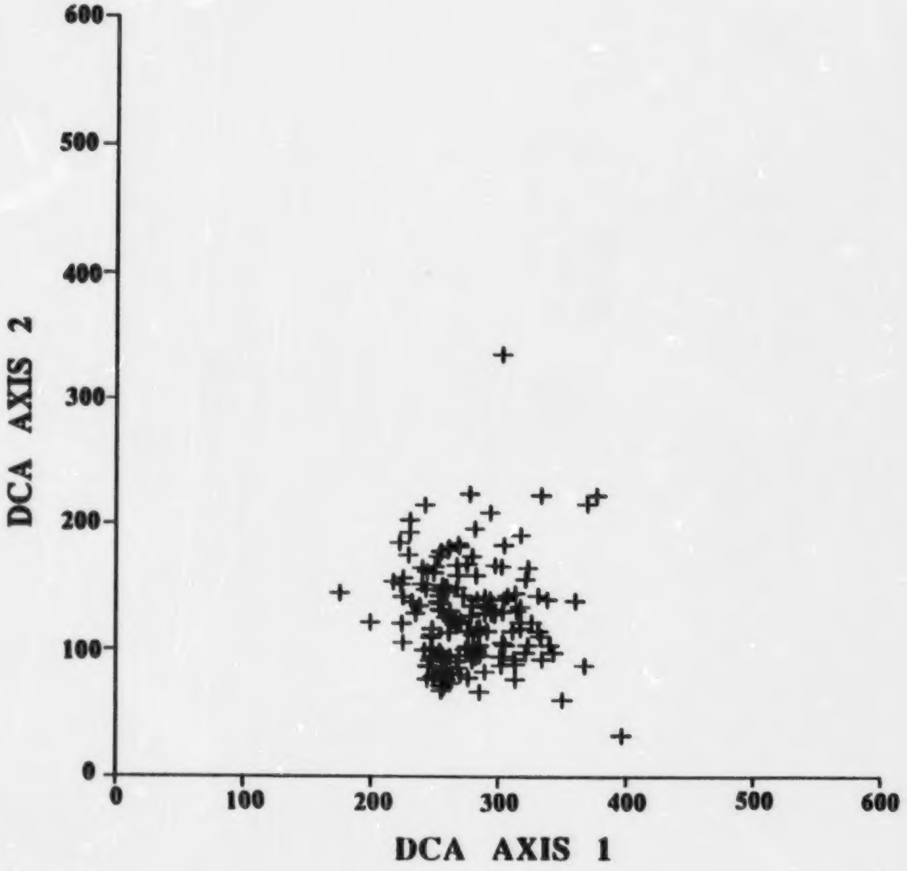

FIGURE 4-4. TWINSPAN GROUP 7

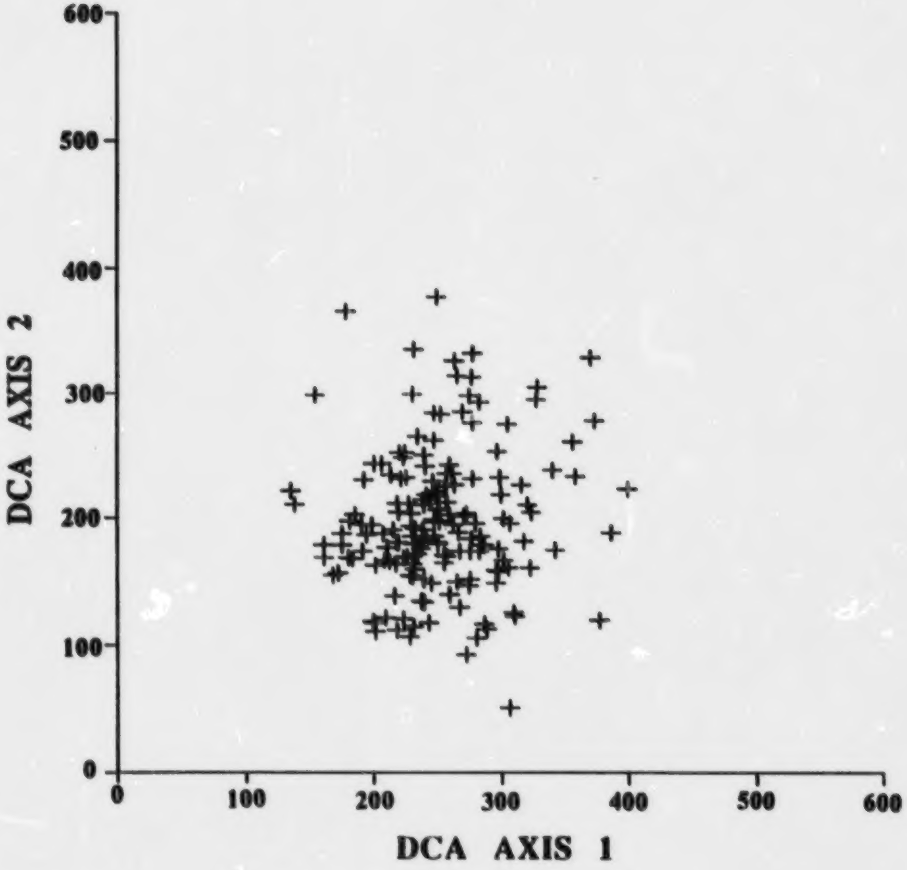

FIGURE 4-5. TWINSPAN GROUP 8

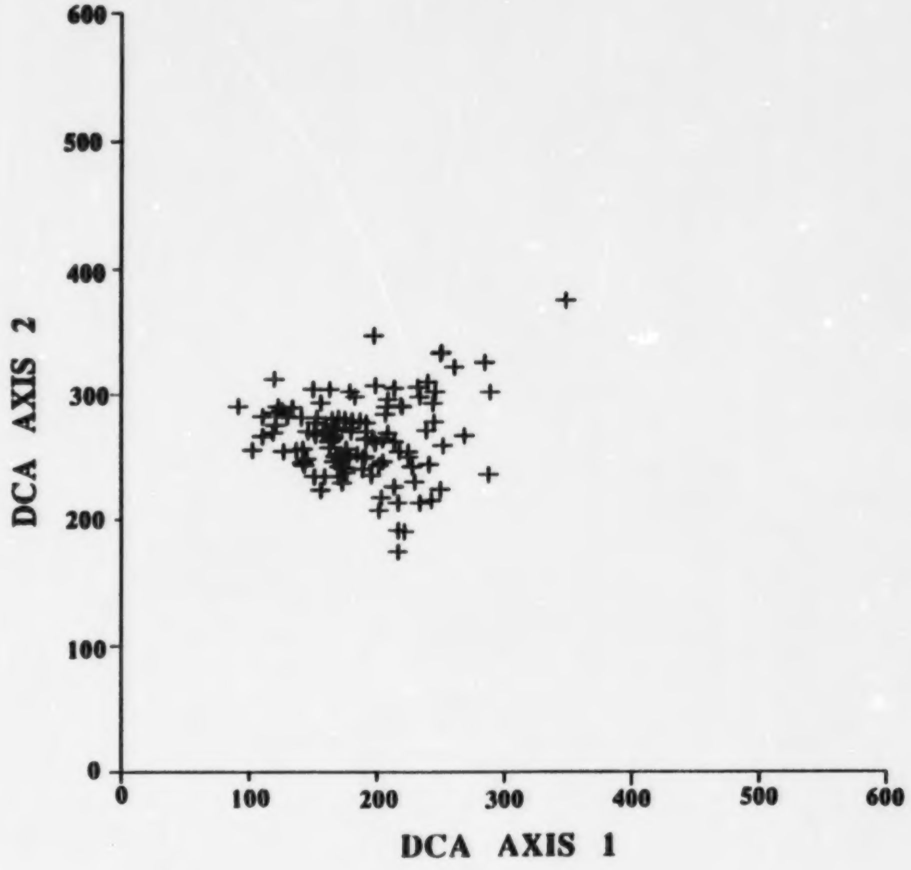

FIGURE 4-6. TWINSPAN GROUP 9

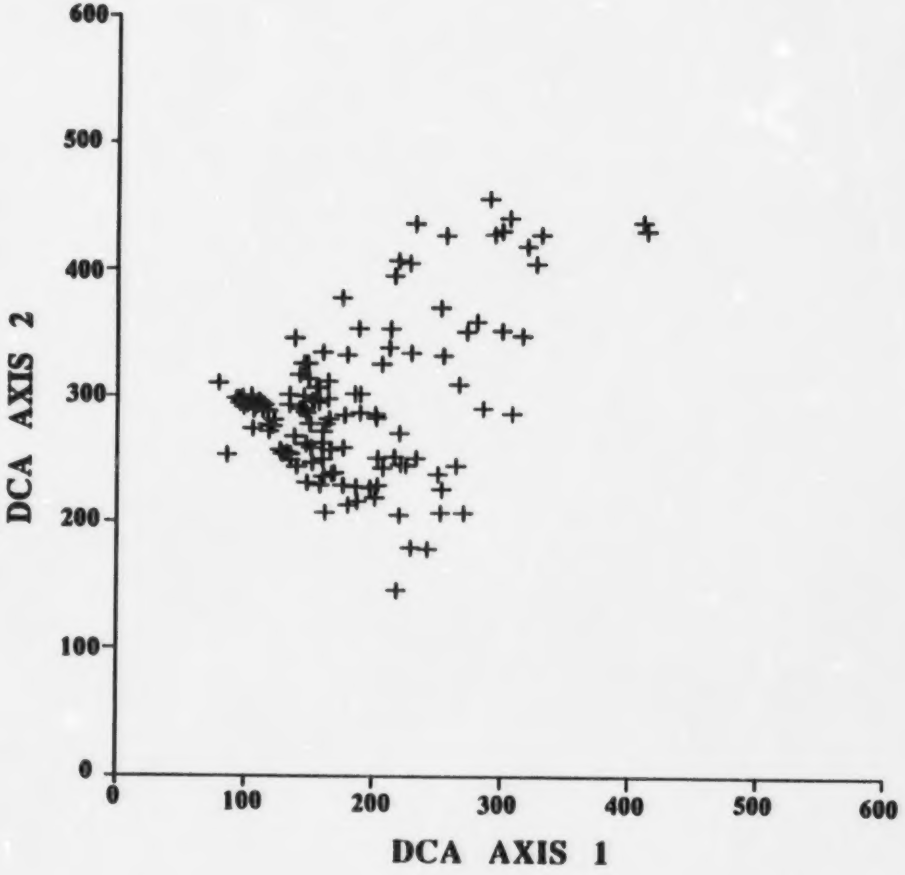

FIGURE 4-7. TWINSPAN GROUP 10

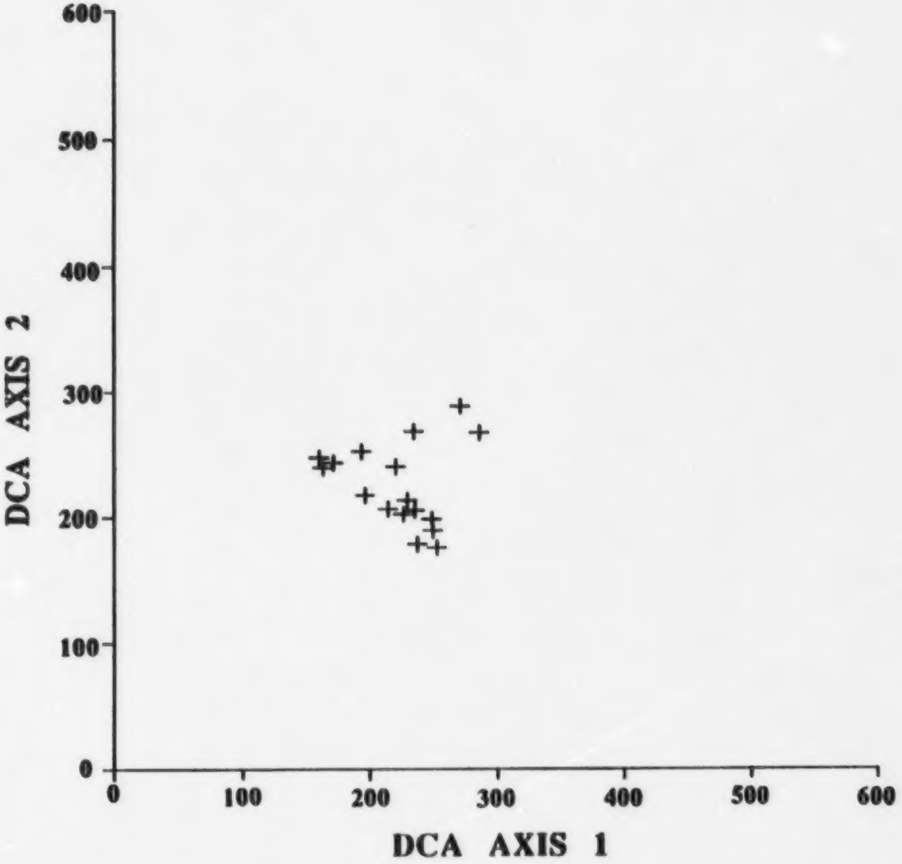

FIGURE 4-8. TWINSPAN GROUP 11

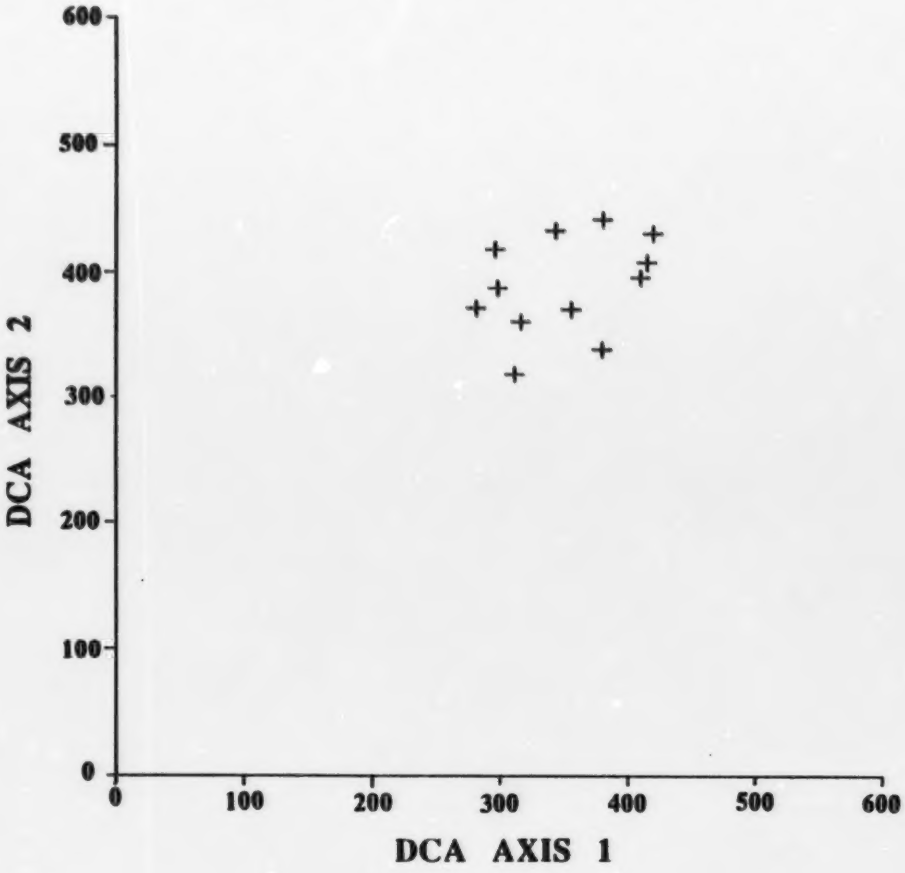

FIGURE 4-9. TWINSPAN GROUP 12

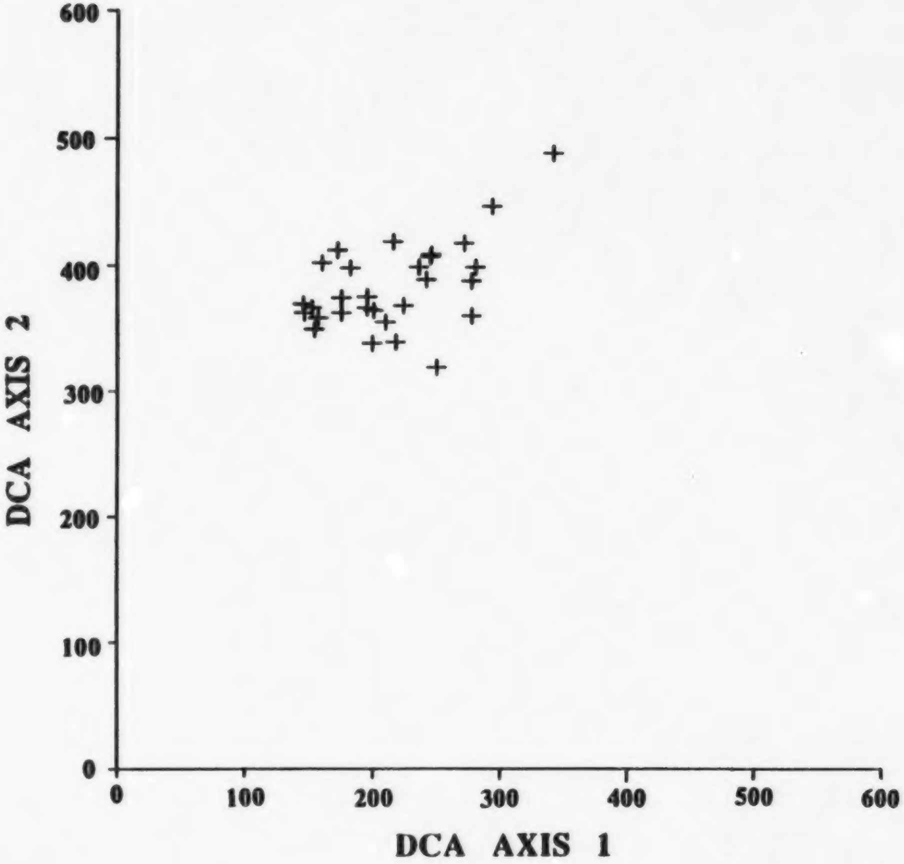

FIGURE 4-10. TWINSPAN GROUP 13

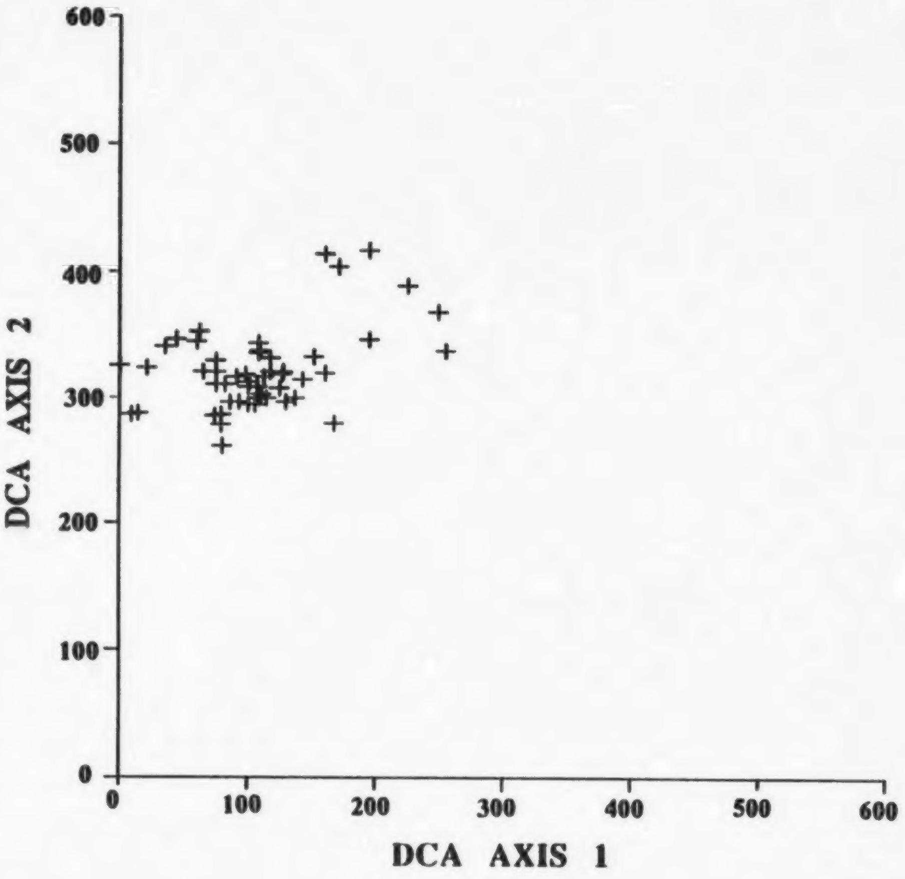

FIGURE 4-11. TWINSPAN GROUP 14

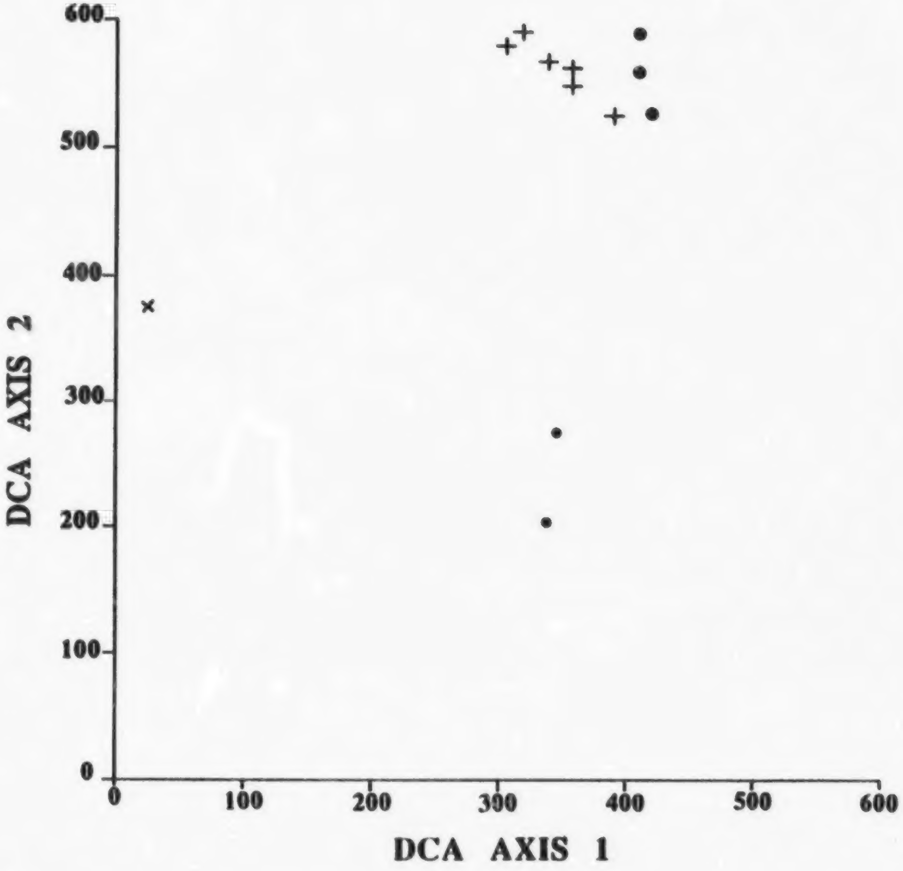

FIGURE 4-12. TWINSPAN GROUPS 1, 2, 4 and 15

1 + 2 ● 4 • 15 ×

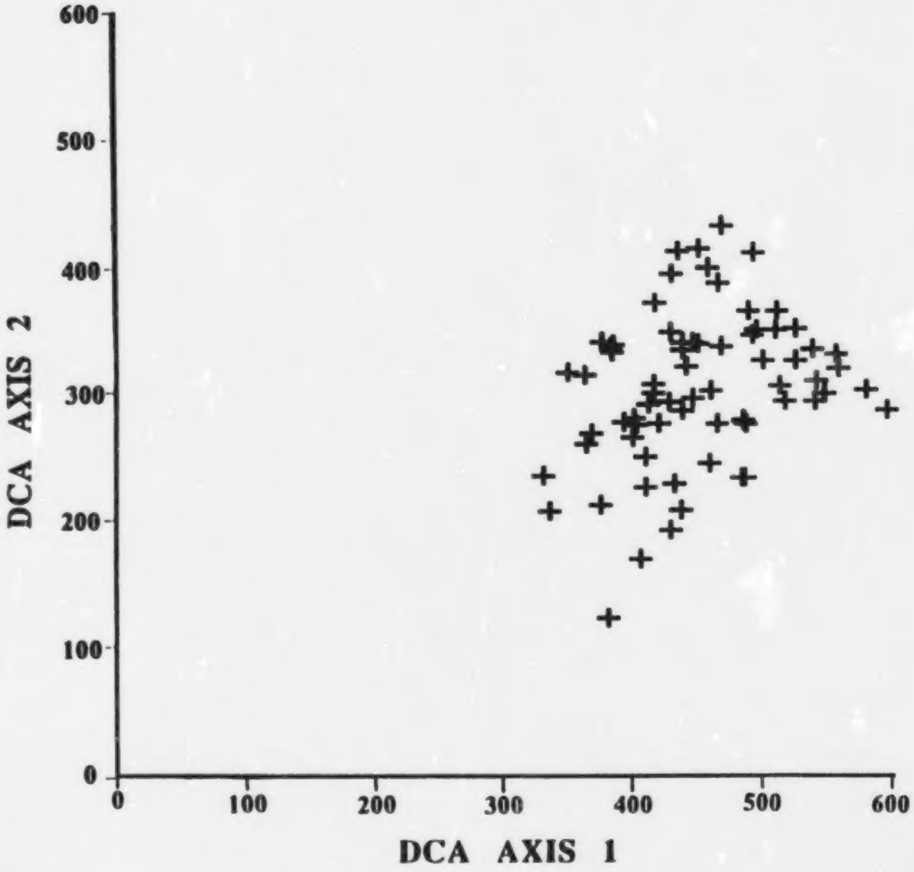

FIGURE 4-13. TWINSPAN GROUP 3A

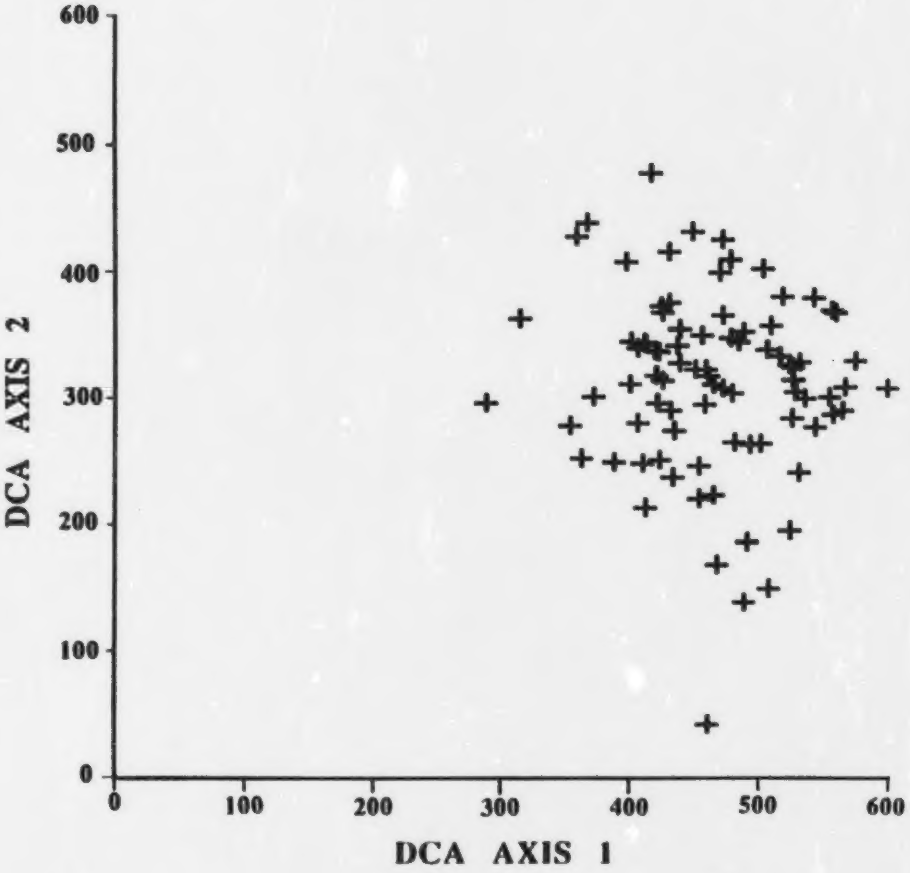

FIGURE 4-14. TWINSPAN GROUP 3B

APPENDIX 5

Tables presenting detailed analytical and statistical comparisons of the vegetation and environmental properties of the **TWINSPAN Groups 3A and 3B** – the two subdivisions of Group 3 at the fifth division level. The data contained in these tables has been summarised in the group descriptions of Appendix 1 and is fully discussed in Appendix 2. The following is a list of the tables, summarizing the information they contain for each of the two groups :

TABLE 5-1.	The percentage frequency of the ground flora species.
TABLE 5-2.	The percentage frequency of the tree species in the variable radius plots, and their mean percentage contribution to the total tree biomass.
TABLE 5-3.	The percentage frequency of the shrubs and small trees.
TABLE 5-4.	The species percentage frequency of the regeneration trees.
TABLE 5-5.	General stand and site attributes.
TABLE 5-6.	Qualitative field soil properties and aspect.
TABLE 5-7.	The mean values for the soil macronutrients and the field-assessed soil properties.
TABLE 5-8.	The mean values for the soil micronutrients.
TABLE 5-9.	The topographical attributes : distance from the coast, distance from nearest road, elevation, slope and corn heat units.
TABLE 5-10.	The mean age, height and 'actual density' of the trees.
TABLE 5-11.	The spatial association with the different ground flora TWINSPAN groups at the 240 sampling sites.

TABLE 5-1. The percentage frequency of the ground flora species in TWINSPAN Group 3 and its two subgroups 3A and 3B. Only species with ≥ 5% frequency in either of the subgroups have been included. For the species listed, only values ≥ 5% are given. Frequencies printed in bold were significantly greater (χ^2 test, $p<0.01$) than the frequency for the same species in all 1200 Inventory plots. The species are listed in the same order as in the data matrix table generated by the TWINSPAN analysis, with those species not listed in that table (mostly the genera) inserted at appropriate points as judged by eye.

SPECIES	TWINSPAN GROUPS			χ^2	All 1200 Plots
	3	3A	3B		
Alnus rugosa	**12**	**11**	**12**		2.9
Aster umbellatus	**16**	**14**	**18**		5.4
Ilex verticillata	**6**		**8**		2.1
Ptilidium pulcherrimum	**13**	9	**17**		4.6
Rosa virginiana	**6**	7			1.7
Aster puniceus	**18**	**25**	12		5.5
Dryopteris cristata	**8**	**10**	6		2.0
Viola spp.	8		**12**		4.2
Epilobium angustifolium	**15**	**24**	8	5.2*	5.2
Equisetum spp.	**12**	**13**	**12**		2.8
Equisetum sylvaticum	**15**	**20**	**12**		3.0
Equisetum arvense	**8**		**12**		1.5
Fragaria virginiana	**33**	**42**	**26**		7.7
Galium triflorum	**33**	**42**	**25**		7.3
Lonicera canadensis	**6**	**10**			1.4
Ranunculus repens	**20**	**18**	**21**		3.8
Rhytidiadelphus triquetrus	**26**	**23**	**29**		5.2
Ribes glandulosum	**6**	**10**			1.5
Rubus pubescens	**69**	**63**	**74**		12.4
Circaea alpina	**7**	**7**	**7**		1.3
Lycopus uniflore	**10**		**14**		1.7
Osmunda cinnamomea	**35**	**20**	**48**	8.1**	7.9
Typha latifolia	**6**		**11**	6.7**	1.1
Athyrium filix-femina	**28**	**45**	**14**	12.0***	5.4
Caltha palustris	**7**		**12**	4.5*	0.9
Cornus stolonifera	**30**	**31**	**29**		4.8
Eupatorium maculatum	**8**		**14**	6.0*	1.3
Galium palustre	**13**		**22**	11.6***	1.8
Impatiens capensis	**44**	**27**	**59**	8.2**	6.3
Mitella nuda	**31**	**27**	**35**		4.8
Mnium spp.	**31**	10	**49**	18.0***	5.0
Onoclea sensibilis	**36**	7	**60**	33.5***	5.3
Prunus virginiana	**8**	**14**		5.4*	1.3
Ribes hirtellum	**8**	**6**	**11**		1.1
Ribes lacustre	**14**	**11**	**17**		2.3
Thalictrum polygamum	**10**	**7**	**13**		1.5
Gymnocarpium dryopteris	**17**	**20**	**14**		3.3
Thelypteris phegopteris	**10**	**16**	6		2.0
Corylus cornuta	**8**	**17**		9.6**	2.8
Acer spicatum	**6**	6	7		2.6
Taxus canadensis	**25**	**23**	**27**		11.2
Dryopteris spinulosa	**42**	**49**	37		26.3
Oxalis montana	5	6			2.9
Sambucus pubens		6			2.6
Streptopus roseus		7			2.6
Viola cucullata	10	11	8		4.8
Viola pallens	**33**	**30**	**37**		16.3

SPECIES	TWINSPAN GROUPS			χ^2[1]	All 1200 Plots
	3	3A	3B		
Aralia nudicaulis	29	37	24		32.5
Prenanthes trifoliolata	8	11			5.2
Rubus canadensis	12	**21**		7.2**	8.5
Rubus strigosus	6	10			4.7
Aster acuminatus	13	17	11		10.0
Pyrola elliptica	10	**16**			5.0
Trientalis borealis	31	54	12	20.5***	44.3
Clintonia borealis	15	28		10.1**	19.8
Coptis groenlandica	19	**24**	14		10.6
Grass spp.	18	**17**	**19**		7.6
Solidago spp.	7	9	6		3.3
Dicranum scoparium	8	11			19.8
Moss spp.	5	7			4.8
Maianthemum canadense	32	41	25	4.3*	58.8
Sorbus americana	9	17		7.5**	8.3
Aster spp.	5	7			4.2
Amelanchier spp.		7			8.3
Cornus canadensis	27	32	22		35.2
Hylocomium splendens	12	7	**15**		6.7
Linnaea borealis	11	**21**		11.4***	10.2
Viburnum cassinoides	20	28	13	5.8*	26.8
Carex spp.	**44**	37	**49**		22.3
Pleurozium schreberi	25	30	21		41.8
Gaultheria hispidula	5		6		3.1
Sphagnum spp.	29	17	**40**	6.2*	13.0
Number of plots	156	71	85		1200
Mean number of species/plot	13.7	14.2	13.3	ns [2]	8.6
Standard error (±)	0.44	0.70	0.56		0.13

1. χ^2 test (d.f. = 1) comparing the percentage frequency of each of the species in Groups 3A and 3B (*** - $p < 0.001$; ** - $p < 0.01$; * $p < 0.05$).

2. z - test, $z = 0.97$ (ns).

TABLE 5-3 The species percentage frequency of the **shrubs and small trees** associated with ground flora TWINSPAN Groups 3A and 3B. (Shrubs/small trees are defined a ≥ 1.3m in height but < 9cm in dbh). Only species with a frequency ≥ 1% in either TWINSPAN group have been listed, and for these species, frequencies of < 2% are indicated by a dot (•). Frequencies in bold were significantly greater (χ^2 test, $p < 0.01$) than the frequencies for the same species in all 1200 Inventory plots.

SPECIES	TWINSPAN GROUP		χ^2 [1]	ALL 1200 PLOTS
	3A	3B		
Conifers:				
Abies balsamea	38	42	ns	40.9
Larix laricina	3	**9**	ns	2.8
Picea glauca	16	8	ns	12.8
Picea mariana		4	ns	5.9
Picea rubens		•	ns	3.5
Thuja occidentalis	**9**	**12**	ns	1.7
Taxus canadensis	**4**	**5**	ns	1.4
Broad-leaved species:				
Acer rubrum	24	22	ns	24.8
Acer pensylvanicum	•		ns	1.6
Acer saccharum	3	2	ns	7.2
Betula alleghaniensis	6	2	ns	7.2
Betula papyrifera	9	14	ns	9.0
Betula populifolia	3	2	ns	1.1
Fraxinus americana	**7**		3.9*	1.1
Fraxinus nigra		**4**	ns	0.25
Populus tremuloides	**16**	11	ns	5.4
Prunus pensylvanica	**17**	•	9.6**	7.2
Sorbus americana	9	4	ns	3.9
Broad-leaved species normally of shrub size:				
Acer spicatum	**14**	**15**	ns	4.3
Alnus rugosa	**18**	**28**	ns	6.2
Amelanchier spp.	•		ns	0.9
Cornus alternifolia	•		ns	0.33
Cornus stolonifera	**3**		ns	0.25
Corylus cornuta	**14**	•	7.3**	2.1
Ilex verticillata	•	**9**	ns	1.7
Nemopanthus mucronata	•	•	ns	2.0
Prunus virginiana	**3**		ns	0.17
Salix spp.	**9**	**12**	ns	2.6
Sambucus pubens	•	•	ns	0.92
Viburnum cassinoides	9	7	ns	7.4
Number of plots	71	35		1200
Mean number of species/plot (± S.E.)	2.5 ± 0.17	2.3 ± 0.12	z=0.83 ns [2]	
Mean number of plants/plot (± S.E.)	9.6 ± 0.95	11.0 ± 1.2	z=0.90 ns [2]	

1. χ^2_{corr} test (df = 1) comparing the percentage frequency of each of the species in Groups 3A and 3B (** - $p < 0.01$; * - $p < 0.05$; ns - not significant).

2. z tests (df = 154) ns - not significant.

TABLE 5-4. The species percentage frequency of the **regeneration trees** associated with ground flora TWINSPAN groups 3A and 3B. Only species with a frequency ≥ 2% in either of the TWINSPAN group have been listed. For the species listed, frequencies of < 2% are indicated by a dot(•). Frequencies in bold were significantly greater (χ^2 test, $p < 0.01$) than the frequency for the same species in all 1200 Inventory plots. (Regeneration trees are defined as ≥ 15cm but < 1.3m in height).

SPECIES	**TWINSPAN GROUP**		χ^2 [1]	ALL
	3A	3B		1200 PLOTS
Conifers:				
Abies balsamea	23	7	5.5*	29.8
Picea glauca	9		5.1*	4.3
Thuja occidentalis	3	2	ns	0.58
Broad-leaved species:				
Acer rubrum	23	12	ns	24.3
Acer spicatum	4	4	ns	1.5
Acer saccharum	3	2	ns	6.0
Alnus rugosa	•	2	ns	0.75
Betula alleghaniensis	6	•	ns	3.0
Betula papyrifera	13	6	ns	6.9
Fraxinus americana	**4**	•	ns	0.58
Prunus pensylvanica	3		ns	2.7
Salix spp.	3	•	ns	0.50
Number of plots	71	85		1200
Mean number of species/plot' (± S.E.)	0.96 (±0.13)	0.46 (±0.081)	z = 3.33 [2] ***	1.6
Mean number of regeneration trees/plot (± S.E.)	3.2 (± 0.54)	2.1 (0.97)	z = 1.0 [2] ns	0.03

1. χ^2 corr. test (d.f. = 1) comparing the percentage frequency of each of the species in Groups 3A and 3B. (* - $p < 0.05$; ns - not significant).

2. z tests: (d.f. = 154) (*** - $p < 0.001$; ns - not significant).

TABLE 5-5. General stand and site attributes for the ground flora TWINSPAN Groups 3A and 3B. For each group the percentage of plots in each class is given. Those percentages printed in bold have made a greater contribution to the χ^2 value than those in plain text - see footnote 1.

ATTRIBUTE	CLASS	TWINSPAN GROUP		χ^2 TEST OF ASSOCIATION [2]			
		3A	3B	χ^2: Row sums	TOTAL χ^2	df	p level
Geographical region	West	59.2	51.8	0.38	0.88	2	ns
	Central	16.9	18.8	0.078			
	East	23.9	29.4	0.42			
	χ^2: Group sums	0.48	0.40				
Woodland size [3]	≤ 5 km²	46.5	40.0	0.37	0.92	2	ns
	> 5 - 10 km²	23.9	23.5	0.002			
	> 10 km²	29.6	36.5	0.55			
	χ^2: Group sums	0.50	0.42				
Forest type	HH (>75% hardwood)	25.4	32.9	0.75	2.07	4	ns
	HS (51-75% hardwood)	35.2	29.4	0.40			
	SH (51-75% softwood)	28.2	23.5	0.32			
	SS (>75% softwood)	7.0	10.6	0.54			
	Other	4.2	3.5	0.04			
	χ^2: Group sums	1.13	0.94				
Stand age	Regeneration	1.4	1.2	1.48	8.39	4	*
	Immature	23.9	15.3				
	Mature	32.4	28.2	0.22			
	Over-mature	5.6	21.2	6.62			
	Uneven-aged	36.6	34.1	0.06			
	χ^2: Group sums	4.57	3.82				
Stocking class	1 (0-25%)	7.0	3.5	0.92	1.68	3	ns
	2 (26-50%)	19.7	25.9	0.63			
	3 (51-75%)	42.3	38.8	0.11			
	4 (76-100%)	31.0	31.8	0.007			
	χ^2: Group sums	0.91	0.76				
Stand origin/history	Old field	**31.0**	**7.1**	**12.34**	31.7	5	***
	Clear cut	11.3	3.5	3.29			
	Partial cut/thinning	28.2	25.9	0.074			
	Swamp	**4.2**	**27.1**	**12.10**			
	Burn	5.6	1.2	0.92			
	Other	1.4	2.4				
	Nothing evident	18.3	32.9	2.99			
	χ^2: Group sums	**17.2**	14.4				
Status in 1935	Forest cover	80.3	90.6	0.36	2.58	1	ns
	Cleared land	19.7	9.4	2.22			
	χ^2: Group sums	1.41	1.17				
Status in 1935 + evident origin	Forest cover	60.6	83.5	2.48	9.22	1	**
	Cleared land	39.4	16.5	**6.74**			
	χ^2: Group sums	5.03	4.19				
NUMBER OF PLOTS		71	85				

1. The percentages for which the corresponding χ^2 value was ≥ 3.84 ($p < 0.05$, df = 1) are printed in bold. Column or row χ^2 sums printed in bold are significant at $p < 0.01$ (for rows: df = 1; for groups df varies with the number of classes, i.e. = n-1).

2. p level = probability level * ($p < 0.05$), ** ($p < 0.01$), *** ($p < 0.001$), ns - not significant

3. For the smallest woodland size category (i.e. ≤ 5 km²), the mean woodland size was 1.36 km² ± 0.20 (S.E.) for Group A and 1.30 ± 0.17 for Group B (z-test: z = 0.27, df = 65, ns).

TABLE 5-6. Qualitative field soil properties and aspect for the ground flora TWINSPAN Groups 3A and 3B. For each group the percentage of plots in each class is given. Those percentages printed in bold have made a greater contribution to the χ^2 value than those in plain text - see footnote 1.

ATTRIBUTE	CLASS			χ^2 TEST OF ASSOCIATION[2]			
		3A	3B	χ^2: Row sums	TOTAL χ^2	df	p level
Soil texture	Clay	2.8	4.7	0.90	22.8	5	***
Fine	Silty clay	9.9	14.1				
Moderately fine	Clay loam	9.9	10.6	4.2			
	Sandy clay loam	32.4	12.9				
Medium	Silty loam	0	0	0.42			
	Loam	4.2	2.4				
Moderately coarse	Sandy loam	21.1	9.4	3.6			
Coarse	Loamy sand	16.9	22.4	1.1			
	Sand	2.8	5.9				
	Organic	**0**	**17.6**	**13.5**			
	χ^2: Group sums	12.4	10.3				
Soil drainage	Well drained	**33.8**	**4.7**	**18.2**	44.8	3	***
	Moderately well drained	28.2	20.0	1.0			
	Imperfectly drained	22.5	10.6	3.4			
	Poorly drained	**15.5**	**64.7**	**22.1**			
	χ^2: Group sums	**24.4**	**28.4**				
Soil Series [3]	Well to rapidly drained series	8.5	1.2	6.1	8.8	2	*
(grouped as four drainage classes)	Well or moderately well drained series	21.1	10.6				
	Imperfectly drained series	21.1	18.8	0.10			
	Poorly drained series	49.3	69.4	2.5			
	χ^2: Group sums	4.8	4.0				
Root restriction factors	Water table	**7.0**	45.9	**7.5**	26.9	1	***
	Soil compaction	**93.0**	**54.1**	**19.3**			
	χ^2: Group sums	**14.6**	**12.2**				
Aspect	Level	**54.9**	**80.0**	3.1	10.1	1	**
	Sloping	**45.1**	20.0	**6.9**			
	χ^2: Group sums	5.5	4.6				
NUMBER OF PLOTS		71	85				

1. The percentages for which the corresponding χ^2 value was ≥ 3.84 ($p < 0.05$, df = 1) are printed in bold. Group or row χ^2 sums printed in bold are significant at $p < 0.01$ (for rows: df = 1; for groups: df varies with the number of classes, ie. = n-1).

2. p level = probability level
   * ($p < 0.05$)
   ** ($p < 0.01$)
   *** ($p < 0.001$)

3. Individual soil series for **Group A** (71 plots): Alberry - 3; Baptist Point - 8; Brackley - 1; Charlottetown - 7; Culloden - 6; Duvar - 3; Haliburton - 4;; Locke Road - 1; Malpeque - 5; Mossy Point - 7; O'Leary - 1; Orwell - 1; Rocky Point - 8; Salt Grass Point - 4; Uigg - 1; West Point - 1; Winsloe - 6; Stream complex - 4. **Group B** (85 plots): Abney Road - 1; Alberry - 2; Baptist Point - 5; Carey Point - 1; Charlottetown - 5; Culloden - 1; Duvar - 4; Haliburton - 2; Lake Verde - 1; Locke Road - 2; Malpeque - 6; Margate - 5; Mossy Point - 8; Orwell - 4; Rocky Point - 16; Salt Grass Point - 1; West Point - 4; Winsloe - 13; Stream complex - 4.

TABLE 5-7. The mean values (± S.E.) of the soil properties at the sampling sites classified in ground flora TWINSPAN Groups 3A and 3B.

SOIL PROPERTY	SOIL HORIZON	GROUP 3A	GROUP 3B	z test [1] (p level)
pH	H	5.37 (0.89)	5.43 (0.12)	0.42 (ns)
	B	6.24 (0.83)	6.35 (0.09)	0.89 (ns)
Carbon (%)	H	16.4 (1.6)	26.5 (1.5)	4.48 (***)
	B	0.44 (0.85)	1.36 (0.83)	10.7 (***)
Nitrogen (%)	H	0.90 (0.078)	1.64 (0.16)	4.08 (***)
	B	0.056 (0.007)	0.095 (.039)	0.98 (ns)
Phosphorus (ppm)	H	131 (17)	97 (6.0)	1.89 (ns)
	B	38.3 (3.9)	48.6 (7.3)	1.23 (ns)
Sulphur (ppm)	H	50.0 (4.6)	94.1 (8.0)	4.76 (***)
	B	11.5 (0.94)	10.8 (1.7)	0.36 (ns)
Potassium (ppm)	H	183 (25)	171 (18)	0.40 (ns)
	B	48.0 (9.1)	44.9 (2.8)	0.32 (ns)
Calcium (ppm)	H	4030 (440)	5930 (380)	3.27 (**)
	B	1060 (214)	1120 (143)	0.21 (ns)
Magnesium (ppm)	H	389 (53)	1040 (190)	3.23 (**)
	B	89.3 (9.3)	135 (17.2)	2.34 (*)
'A' horizon thickness (cm)		24.5 (1.4)	35.8 (2.8)	3.60 (***)
Rooting depth (cm)		61.0 (2.3)	57.0 (3.2)	0.83 (ns)

1. z - test: (df = 154). p level (probability): *** - $p < 0.001$; ** - $p < 0.01$; * - $p < 0.05$; ns - not significant.

TABLE 5-8. The mean values (± S.E.) of the soil micronutrients at the sample sites classified in ground flora TWINSPAN Groups 3A and 3B.

SOIL PROPERTY	**SOIL HORIZON**	**GROUP 3A**	**GROUP 3B**	**z test [1] (p level)**
Boron (ppm)	H	0.72 (0.067)	1.06 (0.83)	3.14 (**)
	B	0.42 (0.24)	0.30 (0.12)	0.46 (ns)
Copper (ppm)	H	1.13 (0.11)	2.23 (0.54)	1.99 (*)
	B	1.48 (1.07)	0.50 (0.045)	0.91 (ns)
Iron (ppm)	H	237 (13.0)	236 (11.8)	0.060 (ns)
	B	110 (7.3)	112 (9.6)	0.13 (ns)
Manganese (ppm)	H	118 (14.9)	100 (20.6)	0.71 (ns)
	B	78.6 (12.4)	66.3 (11.0)	0.74 (ns)
Zinc (ppm)	H	7.2 (0.83)	9.5 (0.78)	2.06 (*)
	B	2.0 (0.80)	0.93 (0.15)	1.35 (ns)

1. z - test: (df = 154). p level (probability): ** - $p < 0.01$; * - $p < 0.05$; ns - not significant.

TABLE 5-9. The mean values (± S.E.) for ground flora TWINSPAN Groups 3A and 3B of the 'topographical' attributes

ATTRIBUTE	**GROUP 3A**	**GROUP 3B**	**z test (p level)**
Distance from coast (km)	4.3 (0.44)	5.0 (0.45)	1.13 (ns)
Distance from road/building (m)	400 (35)	499 (37)	1.95 (ns)
Elevation (m)	19.3 (1.9)	19.7 (1.6)	0.17 (ns)
Slope (degrees)	1.70° (0.22)	1.74° (0.22)	0.11 (ns)
Corn heat units	305 (6.1)	303 (4.9)	0.33 (ns)

TABLE 5-10. The mean values (± S.E.) of the tree properties at the sampling sites classified in ground flora TWINSPAN Groups 3A and 3B. (For tree age and tree height only the greater of the two measured values at each sampling point was used in the calculation of the mean. See the 'Methods' for the definition of 'actual density').

TREE PROPERTY	**GROUP 3A**	**GROUP 3B**	**z test (p level)**
Tree age (yr)	58.9 (2.7)	61.5 (2.3)	0.77 (ns)
Tree height (m)	15.3 (0.35)	13.7 (0.32)	3.3 (***)
Actual density (%)	67.6 (3.7)	69.5 (4.8)	0.30 (ns)

z - test: (df = 154). p level = probability level: *** - $p < 0.001$; ns - not significant.

TABLE 5-11 The spatial association of the ground flora TWINSPAN Groups 3A and 3B with the other groups at the 240 sampling sites. For each group its percentage association with each of the other TWINSPAN groups (including itself) on the same site is given.[1] Those percentages printed in bold have made a greater contribution to the χ^2 value than those in plain test - see footnote 3.

GROUND FLORA TWINSPAN GROUP	ASSOCIATED GROUND FLORA TWINSPAN GROUP												OTHER INVENTORY PLOTS[2]	χ^2 [3]	p level
	3A	3B	5	6	7	8	9	10	11	12	13	14			
3A	**22.9$^+$**	**22.9$^+$**	4.2	**11.3$^-$**	**1.1$^-$**	13.7	7.8	**5.3$^-$**	0.35	1.1	1.1	**1.8$^-$**	6.6	295.6	***
3B	**19.1$^+$**	**33.2$^+$**	5.3	**9.1$^-$**	**0.29**	10.6	10.2	**2.4$^-$**	**0.29$^-$**	1.2	0.88	3.2	**4.1$^-$**	521.1	***
NUMBER OF PLOTS	71	85	77	196	155	165	118	135	21	12	29	51	85		
Percentage Of Plots	5.9	7.1	6.4	16.3	12.9	13.8	9.8	11.3	1.8	1.0	2.4	4.3	7.1		

1. The percentage association was calculated as follows: for Groups 3A and 3B each ground flora plot in a group of five at a sampling site was scored on the basis of the TWINSPAN class of each of the other four plots at that site, and values for all of the plots in TWINSPAN Groups 3A and 3B were totalled. Thus, as an example: the 71 plots of TWINSPAN Group 3A had 284 (ie. 71 x 4) associates - 22.9% of these (ie. 65) were other plots of TWINSPAN Group 3A, 4.2% (ie. 12) were plots of TWINSPAN Group 5, and so on.

2. The 85 'other Inventory plots' comprise the 12 plots in the four small TWINSPAN groups of less than ten plots, plus 53 plots excluded from the analysis because there were no trees at the sampling point, and 20 plots excluded because no ground flora were present in the sample plot.

3. For the two TWINSPAN groups, a χ^2 goodness-of-fit analysis (df = 12) compares the distribution of its observed percentage associations with each of the other TWINSPAN groups, with that expected if the distribution had been proportional to the percentage of the 1200 plots in each TWINSPAN group - ie. to the 'Percentage of Plots' at the base of the Table. Those percentages for which the individual χ^2 values were ≥ 3.84 ($p < 0.05$, df = 1) are printed in bold: a '+' indicates that the level of association was higher than expected, a '-' lower. (For df = 12, if $\chi^2 > 32.91$, $p < 0.001$ - indicated by ***).

APPENDIX 6

INTER-CORRELATIONS BETWEEN THE QUANTITATIVE SOIL AND TOPOGRAPHICAL VARIABLES

The following tables present correlation matrices (Pearson's correlation coefficient) for the inter-correlations between the quantitatively determined soil chemical factors for the H horizon (Table 6-1, degrees of freedom = 1161); the same for the B horizon (Table 6-2, degrees of freedom = 1149); and between the various topographical factors (Table 6-3, degrees of freedom =1198). (Coefficients can vary between +1 and -1, a '+1' indicating perfect positive correlation; a '-1', perfect negative correlation; a '0', no correlation; – within these ranges, the greater the value, the greater the correlation.) With such a high number of degrees of freedom even low levels of correlation can still have statistical significance – as is evident from the results.

Among the variables assessed for the H or humus soil horizon (Table 6-1), % carbon, indicative as it is of the organic matter content, is a key variable, being significantly correlated with practically every other : negatively (at a low level) with pH and iron, positively with a cluster of other variables – i.e. all of the macronutients : in descending order, nitrogen, potassium, calcium, sulphur, magnesium, and phosphorus, plus among the micronutrients, boron and zinc. As we would thus expect most of these macronutrients are in turn positively inter-correlated with each other – with the exception of calcium, which has slight negative correlations with both phosphorus and potassium. Of the other elements, copper shows a positive correlation only with zinc; and manganese with potassium, phosphorus, pH and zinc, while iron is negatively correlated with virtually everything else.

Because the level of organic matter is considerably lower in the B horizon (the lower mineral horizon), many of the correlations evident for the H horizon are not present (Table 6-2). However, % carbon and % nitrogen continue to be positively correlated with each other at a very high level (0.86), and also with magnesium (0.33 for carbon, 0.27 for nitrogen), potassium (0.31, 0.25) , calcium (0.21, 0.19), and zinc (0.15, 0.13). pH is positively correlated with calcium (0.51), magnesium (0.39) and manganese (0.49); negatively with phosphorus (-0.26), nitrogen (-0.17), carbon (-0.14), sulphur (-0.14), and iron (-0.30). Phosphorus, in addition to that with pH, shows a slight negative correlation with calcium (-0.13), magnesium (-0.12) and manganese (-0.11). Copper again shows only a positive correlation with zinc (0.53).

Table 6-3 indicates that there are reasonably high levels of positive inter-correlation (as we would expect) between elevation above sea-level, distance to the coast, and corn heat units; somewhat less between these and slope; and very little or no correlation between any of these and distance to the nearest road or building.

TABLE 6-1. Inter-correlations (Pearson's correlation coefficient) between the soil factors of the H soil horizon (i.e. the humus layer). (D.f. = 1161, all bolded figures are significant at $p < 0.001$; ** - $p < 0.01$; * - $p < 0.05$; ns - not significant.)

	pH	C	N	P	S	K	Ca	Mg	B	Cu	Fe	Mn
C	-0.05*											
N	**0.12**	**0.64**										
P	**-0.09**	**0.26**	**0.16**									
S	ns	**0.36**	**0.26**	0.07**								
K	**-0.13**	**0.53**	**0.31**	**0.71**	**0.17**							
Ca	**0.53**	**0.37**	**0.36**	**-0.11**	**0.28**	-0.06*						
Mg	**0.21**	**0.30**	**0.26**	ns	**0.14**	**0.09**	**0.32**					
B	**0.29**	**0.19**	**0.19**	**-0.09**	**0.19**	ns	**0.48**	**0.18**				
Cu	ns	ns	ns	ns	ns	ns	ns	ns	ns			
Fe	**-0.12**	**-0.14**	**-0.10**	**-0.27**	ns	**-0.24**	**-0.10**	-0.07**	**0.10**	ns		
Mn	**0.14**	ns	ns	**0.38**	ns	**0.32**	ns	ns	ns	ns	**-0.24**	
Zn	ns	**0.45**	**0.28**	**0.44**	**0.14**	**0.55**	**0.12**	**0.16**	ns	**0.18**	**-0.18**	**0.31**

TABLE 6-2. Inter-correlations (Pearson's correlation coefficient) between the soil factors of the B soil horizon (the lower mineral layer). (D.f. = 1149, all bolded figures are significant at $p < 0.001$; ** - $p < 0.01$; * - $p < 0.05$; ns - not significant.)

	pH	C	N	P	S	K	Ca	Mg	B	Cu	Fe	Mn
C	**-0.14**											
N	**-0.17**	**0.86**										
P	**-0.26**	ns	0.08**									
S	**-0.14**	ns	ns	ns								
K	0.06*	**0.31**	**0.25**	ns	ns							
Ca	**0.51**	**0.21**	**0.19**	**-0.13**	-0.09**	0.44						
Mg	**0.39**	**0.33**	**0.27**	**-0.12**	**-0.11**	**0.28**	**0.43**					
B	ns	ns	ns	ns	ns	ns	ns	ns				
Cu	ns	ns	ns	ns	ns	ns	ns	ns	ns			
Fe	**-0.30**	0.08**	0.07*	**0.11**	ns	0.10	-0.06*	ns	ns	ns		
Mn	**0.49**	ns	-0.05*	**-0.11**	**-0.11**	**0.11**	**0.37**	**0.27**	ns	ns	**-0.10**	
Zn	ns	**0.15**	**0.13**	ns	ns	0.09	ns	ns	ns	**0.53**	ns	ns

TABLE 6-3. Inter-correlations (Pearson's correlation coefficient) for five quantitatively measured topographical factors. (D.f. = 1198, all bolded figures are significant at $p < 0.001$; ** - $p < 0.01$; * - $p < 0.05$; ns - not significant.)

	Elevation (m)	Slope	Distance to coast	Distance to road
Slope (°)	**0.17**			
Distance to coast (km)	**0.55**	**0.11**		
Distance to road (m)	**0.12**	ns	0.07*	
Corn heat units	**0.26**	**0.25**	**0.30**	0.07*

APPENDIX 7

SCIENTIFIC AND COMMON NAMES OF PLANT SPECIES MENTIONED IN THIS REPORT

Nomenclature follows that of Erskine (1960, 1985) except for the following (Erskine's names are in brackets): *Acer saccharum (= Acer saccharophorum); Betula alleghaniensis (= Betula lutea); Rhododendron canadense (= Azalea canadensis); Lycopodium flabelliforme (= Lycopodium complanatum Var. flabelliforme); Gymnocarpium dryopteris (= Thelypteris dryopteris); Gaultheria hispidula (= Chiogenes hispidula); Rubus canadensis (= Rubus idaeus* Var. *canadensis); Rubus strigosus (= Rubus idaeus* ssp. *strigosus).*

The 'codes', consisting of the first letters of the Latin generic and species names (or for the trees, the common names), are those assigned during the field data collection and in subsequent analysis - where they differ from the species' names given here it is due to the use in the Inventory of names from Hinds (1986). The common names for the vascular plants are from either Hinds (1986) or Roland & Smith (1969), and for the mosses, liverworts and lichens from Zelazny *et al.* (1989).

Latin Name	Code	Common Name
TREES : CONIFERS		
Abies balsamea	BF	balsam fir
Larix laricina	LA	American larch
Picea glauca	WS	white spruce
Picea mariana	BS	black spruce
Picea rubens	RS	red spruce
Pinus banksiana	JP	jack pine
Pinus resinosa	RP	red pine
Pinus strobus	WP	white pine
Thuja occidentalis	CE	eastern white cedar
Tsuga canadensis	HE	eastern hemlock
TREES : BROAD-LEAVES		
Acer rubrum	RM	red maple
Acer pensylvanicum	STM	striped maple
Acer saccharum	SM	sugar maple
Betula alleghaniensis	YB	yellow birch
Betula papyrifera	WB	white birch

Betula populifolia	GB	grey birch
Fagus grandifolia	BE	American beech
Fraxinus americana	WA	white ash
Fraxinus nigra	BA	black ash
Ostrya virginiana	IW	ironwood
Populus grandidentata	LT	largetooth aspen
Populus tremuloides	TA	trembling aspen
Quercus rubra	RO	red oak
Sorbus americana	SORAM	American mountain ash
Ulmus americana	EM	American elm

SHRUBS		
Acer spicatum	MM	mountain maple
Alnus rugosa	ALNRU	speckled alder
Chamaedaphne calyculata	CHACA	leather-leaf
Comptonia peregrina	COMPE	sweet-fern
Cornus alternifolia	CORAL	alternate-leaved dogwood
Cornus stolonifera	CORSE	red-osier dogwood
Corylus cornuta	CORCO	beaked hazel
Gaylussacia baccata	GAYBA	huckleberry
Ilex verticillata	ILEVE	Canada holly
Kalmia angustifolia	KALAN	sheep-laurel
Ledum groenlandicum	LEDGR	Labrador-tea
Lonicera canadensis	LONCA	fly-honeysuckle
Myrica pensylvanica	MYRPE	bayberry
Nemopanthus mucronata	NEMMU	false holly
Prunus pensylvanica	PRUPE	pin cherry
Prunus virginiana	PRUVI	choke cherry
Rhamnus alnifolia	RHAAL	alder-leaved buckthorn
Rhododendron canadense	RHOCA	rhododendron
Ribes glandulosum	RIBGL	skunk-currant
Ribes hirtellum	RIBHI	gooseberry
Ribes lacustre	RIBLA	bristly blackcurrant
Rosa virginiana	ROSVI	common wild rose
Rubus allegheniensis	RUBAL	blackberry
Rubus canadensis	RUBCA	blackberry
Rubus strigosus	RUBST	wild raspberry
Sambucus pubens	SAMPU	red-berried elder

Sorbus americana	SORAM	mountain-ash
Taxus canadensis	TAXCA	yew
Vaccinium angustifolium	VACAN	blueberry
Vaccinium myrtilloides	VACMY	Canada blueberry
Viburnum cassinoides	VIBCA	wild raisin
Amelanchier spp.	AMELA	serviceberry spp.
Salix spp.	SALIX	willow spp.

FERNS, CLUBMOSSES AND HORSETAILS		
Athyrium filix-femina	ATHFI	ladyfern
Dennstaedtia punctilobula	DENPU	hay-scented fern
Dryopteris cristata	DRYCR	crested wood-fern
Dryopteris spinulosa	DRYSP	wood fern
Equisetum arvense	EQUAR	field horsetail
Equisetum sylvaticum	EQUSY	wood horsetail
Gymnocarpium dryopteris	GYMDR	oak fern
Lycopodium annotinum	LYCAN	bristly clubmoss
Lycopodium clavatum	LYCCL	running clubmoss
Lycopodium flabelliforme	LYCFL	ground cedar
Lycopodium lucidulum	LYCLU	shining clubmoss
Lycopodium obscurum	LYCOB	ground pine
Lycopodium tristachyum	LYCTR	ground cedar
Onoclea sensibilis	ONOSE	sensitive fern
Osmunda cinnamomea	OSMCI	cinnamon fern
Osmunda claytoniana	OSMCL	interrupted fern
Pteridium aquilinum	PTEAQ	bracken fern
Thelypteris noveboracensis	THENO	New York fern
Thelypteris palustris	THEPA	marsh fern
Thelypteris phegopteris	THEPH	beech fern
Equisetum spp.	EQUIS	horsetail spp.

FORBS		
Achillea millefolium	ACHLA	yarrow
Actaea rubra	ACTRU	red baneberry
Aralia nudicaulis	ARANU	wild sarsaparilla
Aster acuminatus	ASTAC	whorled wood aster

Aster lateriflorus	ASTLA	calico aster
Aster puniceus	ASTPU	purple-stemmed aster
Aster umbellatus	ASTUM	flat-topped white aster
Caltha palustris	CALPA	cowslip
Chimaphila umbellata	CHIUM	prince's pine
Circaea alpina	CIRAL	small enchanter's nightshade
Cirsium arvense	CIRAR	Canada thistle
Clintonia borealis	CLIBO	bluebead lily
Coptis groenlandica	COPGR	goldthread
Cornus canadensis	CORCA	bunchberry
Cypripedium acaule	CYPAC	common lady's slipper
Epilobium angustifolium	EPIAN	fireweed
Epigaea repens	EPIRE	mayflower
Eupatorium maculatum	EUPMA	joe-pye-weed
Fragaria virginiana	FRAVI	strawberry
Galium palustre	GALPA	marsh bedstraw
Galium triflorum	GALTR	sweet-scented bedstraw
Gaultheria hispidula	GAUHI	creeping snowberry
Gaultheria procumbens	GAUPR	wintergreen
Hieracium aurantiacum	HIEAU	devil's paintbrush
Hieracium canadense	HIECA	Canada hawkweed
Hieracium floribundum	HIEFL	king devil
Hieracium scabrum	HIESC	rough hawkweed
Impatiens capensis	IMPCA	spotted touch-me-not
Linnaea borealis	LINBO	twinflower
Luzula multiflora	LUZMU	woodrush
Lycopus uniflorus	LYCUN	bugle weed
Maianthemum canadense	MAICA	wild lily-of-the-valley
Medeola virginiana	MEDVI	Indian cucumber-root
Melampyrum lineare	MELLI	cow-wheat
Mitella nuda	MITNU	miterwort
Monotropa uniflora	MONUN	Indian pipe
Oxalis montana	OXAMO	wood-sorrel
Prenanthes altissima	PREAL	white lettuce
Prenanthes trifoliolata	PRETR	lion's paw
Prunella vulgaris	PRUVU	heal-all
Pyrola elliptica	PYREL	shinleaf
Ranunculus acris	RANAC	common buttercup

Ranunculus recurvatus	RANRE	hooked buttercup
Ranunculus repens	RANRP	creeping buttercup
Rubus pubescens	RUBPU	dewberry
Smilacina racemosa	SMIRA	false Solomon's seal
Smilacina trifolia	SMITR	three-leaved false Solomon's seal
Solidago graminifolia	SOLGR	narrow-leaved goldenrod
Solidago macrophylla	SOLMA	large-leaved goldenrod
Solidago rugosa	SOLRU	rough-stemmed goldenrod
Streptopus amplexifolius	STRAM	green twisted-stalk
Streptopus roseus	STRRO	rose twisted-stalk
Taraxacum officinale	TAROF	common dandelion
Thalictrum polygamum	THAPO	meadow-rue
Trientalis borealis	TRIBO	starflower
Trillium cernuum	TRICE	nodding trillium
Trillium undulatum	TRIUN	painted trillium
Typha latifolia	TYPLA	broad-leaved cat-tail
Veronica officinalis	VEROF	common speedwell
Vicia cracca	VICCR	tufted vetch
Viola cucullata	VIOCU	blue violet
Viola incognita	VIOIN	large-leaved white violet
Viola pallens	VIOPA	small white violet
Viola renifolia	VIORE	kidney-leaved violet
Viola septentrionalis	VIOSE	northern blue violet
Aster spp.	ASTER	aster spp.
Solidago spp.	SOLID	goldenrod spp.
Viola spp.	VIOLA	violet spp.

SEDGES AND GRASSES

Carex spp.	CAREX	sedge spp.
	GRASS/POACE	grass spp.

MOSSES, LIVERWORTS AND LICHENS

Bazzania trilobata	BAZTR	bazzania
Cladina rangiferina	CLARA	reindeer moss
Cladina stellaris	CLAST	caribou moss
Dicranum polysetum	DICPO	wavy dicranum

Dicranum scoparium	DICSC	broom moss
Hylocomium splendens	HYLSP	mountain fern-moss
Pleurozium schreberi	PLESC	Schreber's moss
Polytrichum commune	POLCO	common haircap moss
Polytrichum juniperinum	POLJU	juniper haircap moss
Ptilidium pulcherrimum	PTIPU	ptilidium
Ptilium crista-castrensis	PTICR	plume moss
Rhytidiadelphus triquetrus	RHYTR	rough neck moss
Mnium spp.	MNIUM	mnium spp.
	MOSS	moss spp.
Sphagnum spp.	SPHAG	bogmoss spp.

APPENDIX 8

THE TWINSPAN ANALYSIS : The use of the indicator species in classifying the plots.

At each division in the TWINSPAN analysis (see Figure 2), each of the 4 m^2 ground flora plots being considered at that division is assigned an 'indicator score' based on the presence/abundance of particular 'indicator species' – the value of this score determines whether the plot is placed on the negative (i.e. left) side or positive (i.e. right) side in the division. In Figure 2, the negative indicator species for each division are written to the left of the vertical line and the positive indicator species to the right, with the two numbers printed below the horizontal line (e.g. 0 / 1) being respectively, the maximum indicator score for the plot to be assigned to the negative group, and the minimum score for it to be assigned to the positive group (i.e. 0 or less to the left, 1 or greater to the right).

For example, consider a plot at the first division which has only the following indicator species : *Dryopteris spinulosa* (DRYSP) and *Pleurozium schreberi* (PLESC). Such a plot will be assigned –1 for the *Dryopteris* and +1 for the *Pleurozium* – summing these gives a '0' indicator score for the plot. Since this is the maximum value for the plot to be assigned to the left hand side, the plot is thus placed in the group of 595 plots on the left side of the division. By contrast, a plot containing *Viburnum cassinoides* (VIBCA), as well as *Dryopteris* and *Pleurozium*, will be assigned +1,–1, +1 respectively for each species, scoring in total +1 and thus falling to the right side in the division. Note that the codes for some of the indicator species are followed by a number (e.g. DENPU 2) : this means that the percentage cover of *Dennstaedtia punctilobula* in a particular plot must be above a particular level for the plot to be assigned a score of +1 or –1. The numbers following the species codes correspond to cover values as follows : no number listed (i.e. = 1) - > 0% cover (i.e. present at any cover value); 2 - ≥5% cover; 3 - ≥ 10% cover; 4 - ≥ 20% cover; 5 ≥ 30% cover. Thus for example, in the division of the 165 plots on the left side of Figure 2, 'VICCR 3' indicates that *Vicia cracca* would have to be present at ≥ 10% cover for the plot to be given a score, in this case –1.

Knowing the indicator species present in any ground flora plot of 4 m^2 in any forested area on Prince Edward Island will enable that plot to be classified using the TWINSPAN classification in Figure 2 as a dichotomous key – this is in fact how a TWINSPAN classification once set up can then be used to classify 'unknown' sites, and it has been used in this way in Canadian forestry (e.g. Zelazny *et al.* 1989). However, because of the greater probability that a plot of the size of 4 m^2 will not contain all of the species present in the general area (in fact the 4 m^2 plots used in the Inventory contained on average only a third of the species in the area around the plot (Sobey 1993)), chance will play a greater role in the classification of new plots than if a larger plot size (e.g. 100 m^2) had been used in the Inventory.